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Using well-being technology in monitoring elderly people - a new service concept

Jori Reijula

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Abstract

In this study, a new healthcare service concept for monitoring elderly people either at home or in care homes has been developed. As a part of this concept, a simple, but reliable device – Con-Dis – was developed to gain information on the general perceived well-being (PWB) condition of elderly people and on the perceived overall service quality level in care homes for the elderly.

The device was tested in laboratory settings and has since been tested among elderly test subjects. Statistically significant correlations between PWB, mood and quality of life were found, but not with pain. Another test was also performed comparing the Con-Dis device with paper based questionnaire among elderly test subjects in assessing the correlation between the overall quality of service in care homes for the elderly and the food service, clean-up service, medication service, and service provided by the staff. No statistically significant correlations were found between any of the service quality parameters reported by using Con-Dis and paper-based questionnaire. This suggests that the test persons respond differently depending on the two response methods. The device was also used among elderly people along with blood pressure and heart rate monitors and pedometers. A statistically significant correlation was found between PWB and time spent outdoors, but not with blood pressure levels.

The Con-Dis device proved technically reliable, functional, feasible, and informative throughout the development phase and field studies. It can thus be recommended as a part of the new service concept for preventive monitoring purposes for people belonging to risk groups such as the elderly people living either at home or in care homes.

Keywords Perceived well-being, quality of life, Con-Dis, monitoring device, the elderly

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Tiivistelmä

Väestön ikääntyessä vanhusten lukumäärä Suomessa kasvaa yhdessä terveydenhuoltoa tarvitsevien potilaiden kanssa. Julkinen rahoitus terveydenhuollolle on rajallinen, eikä ylimääräisiä resursseja ole terveydenhuoltoalan ammattilaisten lisäämiseen.

Tutkimuksen päämäärä oli luoda uusi terveydenhuoltokonsepti vanhusten monitorointiin joko kotona tai vanhusten palvelutaloissa. Osana konseptia kehitettiin yksinkertainen, mutta luotettava laite – Con-Dis – keräämään tietoa vanhusten koetusta hyvinvoinnista ja palvelun laadusta vanhusten palvelutaloissa.

Laitetta testattiin laboratoriossa sekä kenttäolosuhteissa vanhusten parissa määrittämään mahdollinen yhteys koetun hyvinvoinnin, mielialan, kivun sekä elämänlaadun välillä. Con-Dis laitteen sovelutuvuutta testattiin myös vanhusten hoitolaitosten yleisen palvelun laadun, ruoka-, siivous- ja lääkintäpalvelun sekä hoitohenkilöstön tarjoaman palvelun välillä. Lisäksi laitetta käytettiin verenpaine-, syke- ja askelmittarin kanssa määrittämään mahdollinen yhteys koetun hyvinvoinnin, verenpaineen, sykkeen ja ulkoiluun käytetyn ajan välillä.

Con-Dis-laite osoittautui teknisesti luotettavaksi, toimivaksi ja informatiiviseksi kehitys- sekä kenttävaiheiden aikana. Sitä voidaan suositella osana uutta terveydenhuollon palvelukonseptia ennaltaehkäisevään seurantaan erityisesti riskiryhmiin kuuluville henkilöille ja vanhuksille, jotka asuvat joko kotona tai palvelutaloissa.

Asiasanat	koettu hyvinvointi, elämänlaatu, Con-Dis, monitorointilaitteisto, vanhusväestö		
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ABSTRACT

As the population grows older, the number of elderly people is increasing, along with the burden of patients who need to be treated by healthcare professionals. However, public funding for healthcare is limited and no extra resources are available for increasing the number of professional healthcare staff. Thus, greater efficiency is needed in order to take care of the burden of care.

Elderly people are at greater risk of developing clinical diseases such as diabetes or cardiovascular diseases than younger people. Preventive medicine, in the form of patient monitoring, must therefore be emphasised among the elderly in order to foresee the risk of their developing any of these diseases. The concepts of healthcare that are currently used are insufficient, while monitoring methods are often too complex, slow, and time-consuming for everyday use. The need is growing for a simple and efficient monitoring device to assess elderly people on a daily basis.

The main goal of the present study was to develop a new healthcare service concept for monitoring elderly people either at home or in care homes. As a part of developing this concept, a simple, but reliable device – Con-Dis – was developed to gain information on the general perceived health condition of elderly people.

The Con-Dis device was first tested by faculty members in laboratory settings, where it proved to be reliable and functional. It has since been tested in field circumstances among elderly test subjects (n=10, 7 women, ages between 63-89 years) to assess the correlation between perceived well-being (PWB), mood, pain, and quality of life (QoL). Statistically significant correlations between PWB and mood ($r=0.66$, $p < 0,0001$) and between PWB and QoL ($r=0.68$, $p < 0,0001$) were found, but not with pain.

Another test was also performed using Con-Dis among elderly test subjects (n=10, 6 women, ages between 74-89 years) to assess the correlation between the overall quality of service in care homes for the elderly and the food service, clean-up service, medication service, and service provided by the personnel in elderly care homes. No statistically significant correlations were found between paper-based and Con-Dis reports concerning any of the service quality parameters. The results from the Con-Dis device indicated less satisfaction than those from the paper-based questionnaire and may thus provide more reliable information of the perception of service quality in care homes among elderly care home residents.

The device was also used among elderly people (n=10, 6 women ages between 69-89 years) along with blood pressure and heart rate monitors and pedometers to ascertain the possible correlation between PWB, blood pressure, heart rate, and time spent on outdoor activity. A statistically significant correlation was found between PWB and time spent on outdoor activity ($r=0.62$, $p<0.05$), but not between PWB and blood pressure or heart

rate. The test subjects were in good enough condition to participate in light outdoor exercise.

The Con-Dis device proved technically reliable, functional, feasible, and informative throughout the development phase and field studies. It can thus be recommended as a part of the new service concept for preventive monitoring purposes for people belonging to risk groups, especially among the elderly people living either at home or in care homes.

PREFACE

The present study has been carried out at the Department of Electronics, Helsinki University of Technology, Aalto University, during years 2007-2010.

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CONTENTS

LIST OF PUBLICATIONS

This thesis consists of an overview and of the following publications which are referred to in the text by their Roman numerals.

I Reijula J, Rosendahl T, Reijula K, Linnavuo M, Sepponen R. A simple and countable method for the assessment of perceived well-being among elderly people. International Journal on Smart Sensing and Intelligent Systems 2009; 2(2): 279-292

II Reijula J, Rosendahl T, Reijula K, Roilas P, Roilas H, Sepponen R. A new method to assess perceived well-being among elderly people – a feasibility study. BMC Geriatrics 2009; 9:55

III Reijula J, Rosendahl T, Reijula K, Roilas P, Roilas H, Sepponen R. New method to assess service quality in care homes for the elderly. International Journal of Smart Sensing and Intelligent Systems 2010; 3(1): 14-26

IV Reijula J, Rosendahl T, Reijula K, Roilas P, Roilas H, Sepponen R. A new method to assess perceived well-being among elderly people – a follow-up study. International Journal of Smart Sensing and Intelligent Systems, 2010; 3(2): 130-145

LIST OF ABBREVIATIONS

ADL	Activities of daily living
AF	Atrial fibrillation
CVD	Cardiovascular disease
DM	Diabetes Mellitus
ECG	Electrocardiograph
EFSL	Embedded Filesystems Library
EMD	Electronic mood device
EPROM	Erasable Programmable Read-Only Memory
ESP	Experience Sampling Program
FAT	File Allocation Table
GP	General Practitioner
HAD	Hospital Anxiety and Depression Scale
HRQL	Health-related quality of life
LCD	Liquid Crystal Display
MD	Musculo-skeletal disorder
PC	Personal computer
PDA	Personal digital assistant
PIPER	Prompting Intensity of Pain, Electronic Recorder
PGWB	Psychological General Well-being Scale
PWB	Perceived well-being
QoL	Quality of life
RAI	Resident Assessment Instrument
RAM	Random access memory
RaVa	Rajala-Vaissi index
RFID	Radio-frequency identification
SD	Secure Digital
SF-36	Medical Outcome Study 36-item Short Form Survey
VAS	Visual analogue scale

1 INTRODUCTION

The population in Finland and in the developed countries in general is aging rapidly. Compared to the rest of Europe, the aging of the population is fastest in Finland (Statistics Finland 2010). People have been allowed to live longer lives partly due to development in medical science and technology, but no proven cure for most chronic diseases has been achieved thus far (Izaguirre 2004). At the same time, diseases common in elderly people, such as type 2 diabetes and cardiovascular diseases (e.g. heart disease and strokes), are on the rise (Kopelman 2000). In addition, diseases such as cancer, hypertension, metabolic syndrome, obstructive sleep apnea syndrome, osteoarthritis, depression, disability, Alzheimer's disease, and other cognitive declines have also grown in number (Salihu et al. 2009).

The primary healthcare system in Finland is currently organised in such a way as to encourage apparently healthy elderly persons stay at home as long as possible. After an acute disease with health impairments (such as respiratory infection, CVD, psychiatric and neurological diseases), elderly patients are moved into a local central hospital's intensive care unit. From there, the patients are moved into the inpatient ward of the municipal healthcare centre. After recovering from a disease the patients are either allowed to go back home, stay in the inpatient ward of the health care centre, or are moved to a care home for the elderly with nursing provision.

However, the current healthcare organisation suffers from severe limitations. The major flaw of the system is that the resources of municipal social and health care staff are too limited in order to be provided for helping the elderly to cope with living at home. This is mainly due to the fact that the healthcare systems in developed countries are under severe financial stress and the resources for healthcare are scarce (Dai et al. 2009). Pressure is being exerted on healthcare professionals to take care more efficiently of the increasing number of elderly people and their sicknesses, since total expenditure on healthcare and the care of the elderly increases with age (Häkkinen 2008). Assessing – and, it is hoped, reducing – healthcare costs are crucially important now and will be in the near future (Donnelly 2010). A new service concept is needed to offer sufficient treatment for the increasing elderly population with substantially fewer costs and resources.

First of all, having elderly people staying in beds of hospital wards should be minimised as far as possible in the imminent future to reduce healthcare costs (Kehlet 1997). Alternatives for the care of the elderly must be sought by developing preventive healthcare (Stults 1984). It is an essential and fundamental development for healthcare professionals to foresee and prevent diseases from occurring instead of treating them afterwards (Kivelä and Pahkala 2001, Rumsfeld et al. 2003, Herrmann-Lingen et al. 2001, Schwenzfeier et al. 2002). This is especially the case among those in risk groups, including elderly people. Elderly citizens' own responsibility for their healthcare and coping on their own should be increased; better physical condition and health guarantee

a longer self-reliant period of coping time for the elderly in their own homes (Stults 1984). On the other hand, families' responsibilities for their elderly members should be emphasised in the near future and the role of the third and private sectors in taking care of the elderly should grow. The elderly should be encouraged to stay at home so that their relatives can provide care and nurture for them for as long as possible.

For this to happen, high-quality real-time monitoring systems that provide links between homes and hospitals are needed for the patients' doctors and nurses to monitor their elderly patients. Special attention should be paid to patients with a risk of acute seizures, such as strokes. Nowadays, nurses often pay visits to patients but in the future there will not be enough resources for them to continue doing this. A new service concept, which provides the nursing staff with the same information without having to perform visits to the patients, must be designed. A video-based connection presenting clearly visible and audible feedback on the patient must also include information parameters on the patient's vital body functions. An example of this is Intel's new Health Guide PHS6000 – a monitoring system that presents the vital signs of the patient to the doctor and also enables video conferences between the two to take place (Intel 2010). The device makes sure the patient remembers to measure the required signals and sends the data to a doctor for analysis (Intel 2010). However, the machine's findings are not designed to replace visits to the doctor and thus if any problems persist, the patient needs to see a specialist (Intel 2010). Thus a more extensive service system is still needed to provide information to the nursing staff, including: vital functions (blood pressure, heart rate, body temperature, and blood glucose); movement (pedometer, positioning system, and floor sensor system (Henry et al. 2008)); a video phone connection (for doctors, relatives, and friends), an entertainment service (music, television, culture, chatting, and video games), and a food and dry-cleaning service (social services).

Developing well-being technology for the care of the elderly is a significant opportunity and one which needs to be taken. Apart from a few innovations, technical applications have been used surprisingly little thus far. As discussed, technology helps elderly people to stay home for longer and reduces the need to resort to care homes for the elderly or hospitalisation. Utilities for physically challenged elderly people and systems for close relatives and nursing staff, such as a video phone and internet connections and healthcare devices, can ideally support an elderly person to cope at home for longer than at present. Developing these systems not only increases the possible length of time they can stay at home but also increases patient safety, activity, perceived well-being (PWB) – commonly regarded as subjective psychological well-being, and quality of life (QoL) (Vincent et al. 2006, Cooper RA and Cooper R 2010, Rose-Rego et al. 1998).

Interview and survey methods have been used earlier in healthcare when patients have been monitored (Ebner-Priemer 2007). Paper-based forms and questionnaires, such as Resident Assessment Instrument (RAI) and Rajala-Vaissi index (RaVa), which are still widely used in the hospital environment, are time-consuming and cause strain on doctors and nurses, who often have to deal with them for hours on a daily basis (Gray et al. 2008, Chaliner et al. 2003, Voutilainen and Vaarama 2005, Voutilainen et al. 2004).

Thus voluntary self-monitoring and also self-medication among elderly people should be emphasised in order to lighten the burden on healthcare professionals (Krampen 2008). Technological advances such as wireless data communication and improved sensor technology have made self-monitoring a feasible option for elderly people with limited physical abilities.

Well-being technology has been utilised in a variety of applications for fitness, coaching, and athletes. However, the healthcare sector has deployed few well-being applications successfully. The greatest need for self-monitoring applications is among the elderly, but they have been reluctant to capitalise on new technical innovations (Van Bronswijk et al. 2002). Limited technical skills and prejudice against new technological applications could explain why elderly people have not shown greater interest in new well-being technology.

In the present study, first, an attempt was made to evaluate the need for general monitoring systems for elderly people staying either at home or in care homes for the elderly. Second, we developed and tested the field circumstance reliability and feasibility of a new, simple but countable electronic device – Con-Dis – to fulfil the need for monitoring PWB. The aim of the device is to quickly and effortlessly provide information concerning elderly test persons' PWB.

In addition to assessing the PWB of elderly people, understanding the needs of the elderly in care homes is of great importance in order to provide them with better services (Hancock et al. 2006, Worden et al. 2006). However, several studies have suggested that most currently used assessment methods (mainly questionnaires and interviews) and instruments often prove to be unreliable and may provide misleading information (Williams 1994, Rubin 1990, Sitzia 1999). Thus there is an urgent need to develop more dependable methods to assess service quality in care homes for the elderly, which was another aim of the research project.

Finally, on the basis of extensive research and field studies among elderly patients, a new service concept has been created for elderly people to enable them to continue living at home or in care homes for the elderly in order to avoid hospitalisation. The Con-Dis device was created and assessed as a part of this new service concept.

2 REVIEW OF LITERATURE

2.1 Aging and health

In gerontology and geriatrics, the common definition of “elderly” means people aged 65 years and older (Orimo et al. 2006). This has also been the conventional conception in developed countries (Orimo et al. 2006). However, the term “elderly” does not denote “retired”, which is also the case in the present study.

Among medical research, the term “old people” has been used rather loosely and its meaning has changed during the last century (Palmore 1999). Some have defined “old people” as people between ages 60-80 years (Vinding et al 2009), whereas in gerontology a common definition is that people over the age of 65 are considered “old” (Palmore 1999). In gerontology, people between 65-74 years of age have been commonly referred as “young-old”, people between 75-84 have been named the “middle-old”, and those over 85 years the “old-old” (Palmore 1999).

Another term, “senior citizens” has also been frequently used in gerontology. People aged 65 years and older are commonly regarded as “senior citizens” (Scudds and Robertson 2000, Nichol et al 1998).

2.1.1 Aging demography in developed countries

Population aging is a global phenomenon (WHO 2010). Rapid declines in mortality rates and increases in population have occurred alongside declines in fertility rates throughout the whole world during the past century (Lunenfeld 2008). Furthermore, the trend is highly likely to continue in the future (Lunenfeld 2008). It has been estimated that the population aged 60 and over in the world was 600 million in the year 2000 and that the number will rise to 1.2 billion by the year 2025 (Goldacre 2009). Nowadays, approximately half of the world’s elderly population lives in the developed world and they comprise 16% of the population in Europe (Goldacre 2009).

The implications of an aging population are manifold (WHO 2010). The dependency ratio – the ratio of number of people who do not work compared to those who do – is increasing. Typically, women outlive men in almost all societies and by the time they reach an age over 85 years the ratio between women and men is close to 2:1 (WHO 2010). Social support and medical care needs increase with advancing age (Stults 1984). The total burden of diseases will increase for those disorders that are strongly related to increasingly old age (Stults 1984). Higher dependency levels due to old age along with a risen number of elderly women living alone will cause problems for after-care in patients who are successfully treated for acute chronic illnesses (Goldacre et al. 2009).

The level of dependency increases quickly with age, which can be observed clearly from Figure 1.

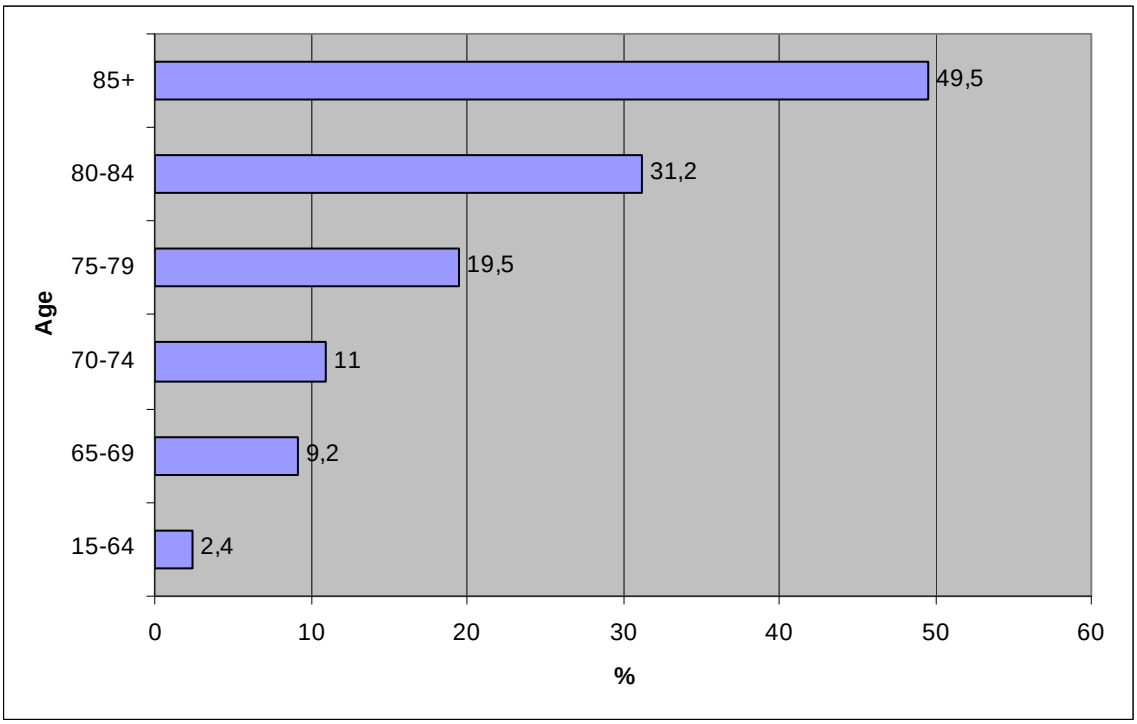

Figure 1. Percentage of people needing help with everyday activities by age (1991) (Modified from Mann 2005).

Finland, along with the other developed countries, is undergoing a major change in demographics. The middle-aged and elderly age groups are growing quickly, while the number of adolescents and young adults is decreasing (Statistics Finland 2010). Finland already has the fourth oldest median age in the world, at 41.8 years, and it is estimated that it will grow steadily in the future (UN Population Division 2009).

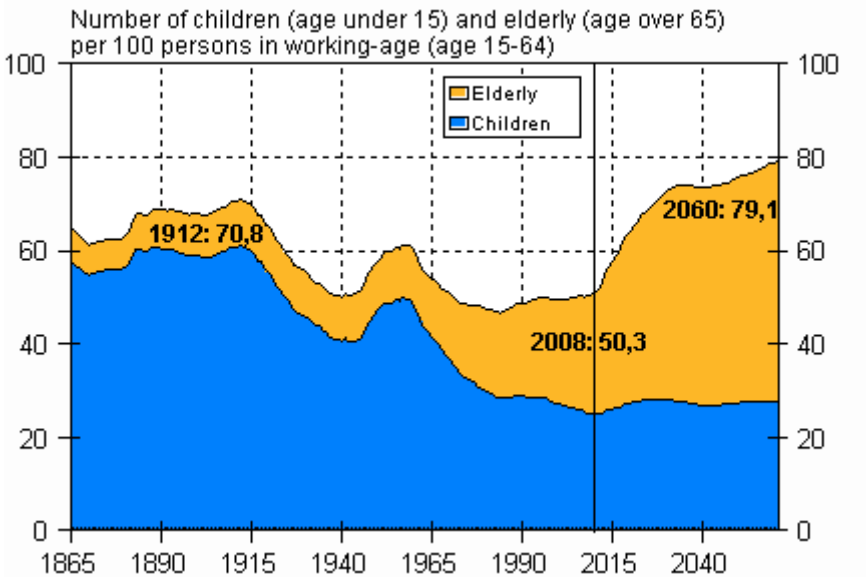

Figure 2 – Demographic dependency ratio in Finland during the years 1865-2060 (Statistics Finland 2010).

Figure 2 shows the demographic dependency ratio, the number of children and pensioners per one hundred persons of working age, among the total Finnish population. In 1912 the demographic dependency ratio was 71, of whom 60 were elderly. In 2008 the demographic dependency ratio was 50, of whom 23 were elderly. According to the projection it is estimated that the ratio will be 79 in 2060 (Statistics Finland 2010). The number of elderly persons aged 65 years and above will almost double from the present 905,000 to 1.79 million and it is estimated that their proportion of the population will rise from 17 to 29 per cent by 2060 (Statistics Finland 2010). It is estimated that the proportion of persons aged over 85 in the population will rise from 2 to 7 per cent, and their number from the present 108,000 to 463,000 (Statistics Finland 2010). However, the proportion of people of working age will diminish from the current 66 per cent to 56 per cent by 2060 (Statistics Finland 2010). Thus the demographic dependency ratio will rise quickly in the near future. This is crucially important knowledge, since a higher dependency ratio, for example, will significantly raise the tax rates in Finland.

2.1.2 Health effects associated with aging

Elderly people are more likely to suffer from chronic physical and mental illnesses and to require costly medical care than younger persons (Ouslander and Beck 1982). They currently occupy over 90% of nursing home beds and the number is expected to grow rapidly in the near future (Ouslander and Beck 1982). It has also been estimated that nearly 90% of the elderly do not regularly visit a personal physician (Kennie 1984) and many fail to report their illnesses and health needs until they reach an advanced stage of

disease and disability, when therapeutic interventions may be less effective (Ouslander and Beck 1982, Williamson 1981).

The health effects of aging are both physical and psychological (Stults 1984). Aging is a cause of severe degradation in the human body and thus several diseases and disorders are more frequent among old people than among younger people (Stults 1984). Elderly people also suffer more from chronic illnesses and disabilities and require more costly treatment (Stults 1984). Thus it is essential to be aware of their most common health conditions.

Diabetes mellitus (DM) is a common health problem for the aging population and its prevalence increases with increasing age (Noth et al. 2009, Iwata and Munshi 2009). Currently, over 20% of patients older than 65 years have DM and the percentage is expected to grow during the coming decades (Viljoen and Sinclair 2009). DM is associated with an increased prevalence and incidence of functional disabilities, depression, falls, urinary incontinence, malnutrition, cognitive impairment, and Alzheimer's disease (Araki and Ito 2009, Shimada et al. 2009).

Neurological disorders such as Alzheimer's disease also have a close correlation with aging (Baquer et al. 2009). Among elderly people, dementia is clearly one of the most common neurological disorders (Bellomo et al. 2009). Medically ill elderly persons' prevalence rates of depression are remarkably high as well (Strober and Arnett 2009). For example, the prevalence rates of depression among Alzheimer's, stroke, and Parkinson's patients were respectively 87%, 79%, and 75% (Strober and Arnett 2009).

Brain- related cardiovascular disease and paralysis are numerically among the most common diseases among the elderly (Figure 3). Concomitant CVDs, such as arterial hypertension, increase the risk of strokes (Hentschel and Gahn 2008). In Finland, strokes are a major risk factor for the elderly and because of the rapid aging of the population, the number of stroke patients is likely to increase considerably (Sivenius et al. 2009). While the incidence of strokes in patients aged between 55 and 64 years is 0.2-0.3%, the rate is 2-3% in patients aged 85 years and over (Hentschel and Gahn 2008). A stroke after a brain thrombus can immobilise an elderly patient for several weeks. A patient who has been lying in bed for several weeks can seldom regain the ability to walk. The prevalence of chronic heart failure (CHF) is also age-related affecting 5% of people aged between 65 and 80 years (De Lusignan et al. 2001). Another age-related disease is atrial fibrillation (AF), which disproportionately affects men, deteriorates QoL, causes morbidity and mortality, and imposes a major clinical and economic burden, which will continue to increase in the future (Sanoski 2009).

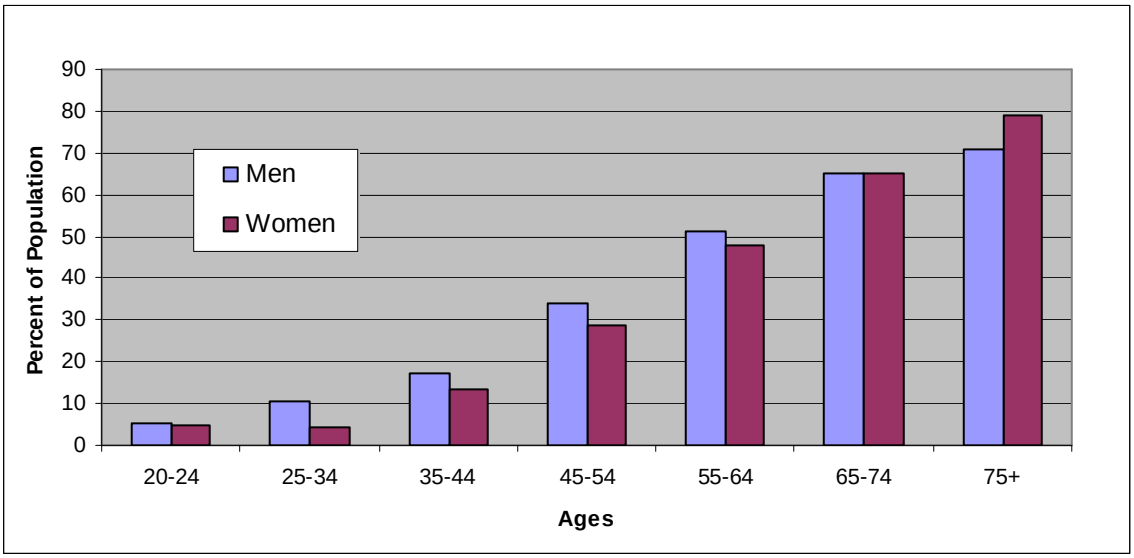

Figure 3 – Prevalence of cardiovascular diseases among American adults by sex and age (modified from Mann 2005).

Depression is one of the most common disorders among the elderly in the developed countries. Among elderly Finnish residents the depression prevalence for men has been 22%, and for women nearly 30% (Kivelä et al. 1988). Depression is closely associated with female sex, widowhood and being in long-term institutional care or receiving home nursing or help (Kivelä et al. 1988). The occurrence of depression is not age-related and does not have a close statistical correlation with education or occupation (Kivelä et al. 1988). However, exercise has been proven to improve mental condition of depressed patients (Kivelä and Pahkala 2001).

Obesity is on the rise among the elderly population worldwide (Salihu et al. 2009). It also significantly increases healthcare costs, and hospitals and nursing homes are often not sufficiently equipped to serve the obese elderly (Salihu et al. 2009). Obesity exposes an elderly person to variety of morbidity conditions such as cancers, DM, hypertension, strokes, heart disease, metabolic syndrome, obstructive sleep apnea syndrome, osteoarthritis, depression, disability, and lower scores on QoL measures (Salihu et al. 2009). Obesity has also been associated with Alzheimer's disease among with other forms of cognitive decline (Salihu et al. 2009).

Other typical diseases among the elderly are anaemia, thyroid dysfunction, osteoporosis, prostate cancer, and musculo-skeletal disorder (MD) (Cluett and Melzer 2009, Fowler et al. 2000, Webster 1979, De Craen & Gussekloo 2003). Urinary incontinence is also an escalating medical, social, and economic health concern for elderly people and its assessment and treatment negatively affect their QoL (Akkoç et al. 2009). A few of the most common diseases among the elderly aged 85 years are shown below (Table 1).

Table 1 – Common disease prevalences for elderly people aged 85 years (modified from De Craen & Gussekloo 2003).

Clinical abnormality	Percentage (%)
Anaemia	30
DM	16
Thyroid dysfunction	7
Atrial fibrillation	10
Hypertension	71

Table 2 illustrates the difference between hospital admission rates for people aged 55-59 years compared to the "old old", which means elderly people over 85 years of age. The significant increase of prevalence with age can be clearly noted.

Table 2 – Hospital admission rates per 100,000 resident population for elderly people of ages 55-59 years and 85+ years for males and females (modified from Goldacre 2009).

Disease name	55-59 years (males)	55-59 years (females)	85+ years (males)	85+ years (females)
Gastric ulcer	50.6	45.7	177	149.6
Vascular disorders of intestine	6.5	7	70.7	77
Diverticular disorders of intestine	118	151.8	417	466
Malignant neoplasms of oesophagus	47.5	13.8	162.7	91.5
Malignant neoplasms of stomach	28.6	10.4	200.9	89.2
Malignant neoplasms of colon	63.6	50.5	323.4	219.7
Malignant neoplasms of pancreas	21	15.1	92.2	80.4
Abdominal and pelvic pain	270.4	412.5	481.8	466.6
Nausea and vomiting	30.4	46.1	150.4	205.4
Dysphagia	44.4	51.4	175.6	146.8

Table 3 – Leading causes of death among persons aged 65 years and older (modified from Sahyoun et al. 2001)

#	Cause of death
1	Heart disease
2	Cancer
3	Stroke
4	COPD
5	Pneumonia / Influenza
6	DM

Table 3, illustrating the leading causes of death among the elderly, is presented above. Recently, heart disease and cancer have been the two leading causes of death among elderly persons, causing close to a million deaths among elderly Americans in 1997. Other important chronic diseases among persons 65 years of age and older include strokes (CVD), chronic obstructive pulmonary diseases (COPD), pneumonia, influenza,

and DM. COPD entails chronic bronchitis, emphysema and asthma along with other chronic respiratory diseases. Smoking is commonly considered to be the main reason for COPD-related deaths. Alzheimer's disease and numerous prominent renal diseases have also become major causes of death among the elderly. Injuries remain a frequent cause of death among the elderly and they are mostly caused by motor vehicle crashes, firearms, suffocation and falls (Sahyoun et al. 2001).

2.1.3 Functional capacity

Functional capacity closely associates with elderly persons' PWB and it also strongly defines their experience of quality of life. Although elderly persons' functional capacity is defined by several parameters, sicknesses and diseases causing functional limitations and ultimately disabilities are of great concern and must therefore be more closely examined. Functionally limited or disabled elderly persons are not only limited in their daily work and other activities, but must also be taken care of. Also, from well-being technology standpoint, diseases causing functional disabilities present an intriguing challenge: Can well-being technology improve functional capacity among elderly people by preventing and curing disabling diseases? Figure 4 illustrates development of the disablement process for an elderly person:

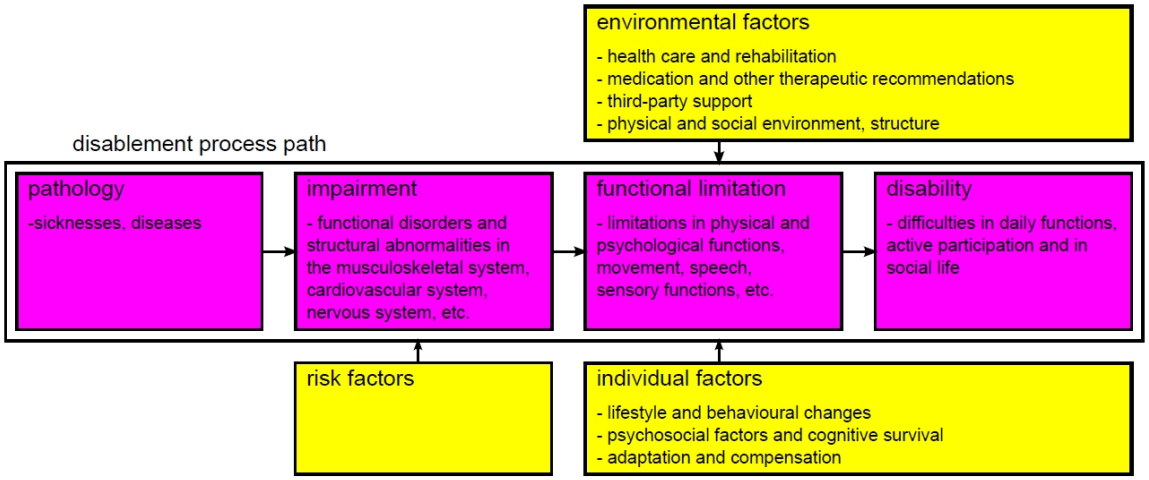

Figure 4 – Disablement process development model (modified from Heikkinen and Rantanen 2008)

In the disablement process development model, created by Verbrugge and Jette in 1994, chronic and acute diseases cause damages in different structures and functions of the organ system. On the other hand, limitations in the physical and psychological functions affect coping with daily activities. In the model, individual and environmental factors either accelerate or decelerate the disablement process. However, it is to be noted that in real life these events do not always proceed in chronological order according to the model. The direction may in some cases be opposite to the one depicted. (Heikkinen and Rantanen 2008). Table 4 shows the most noteworthy diseases among elderly people in Finland:

Table 4 – Prevalence of most common diseases among elderly people (over 65 years of age) in Finland and their effect to functional capacity (modified from Heikkinen and Rantanen 2008).

Disease name	Men (%)	Women (%)	Effect to functional capacity
Coronary heart disease	31,7	22	Increased risk of chest pain due to physical stress. Decreased mobility, ability to exercise, physical capacity and HRQL. Effects from minor to significant.
Asthma	7,6	10,4	Increased risk of respiratory symptoms (wheezing and dyspnea) due to several agents and exercise. Decreased mobility, ability to exercise and physical capacity. Effects from minor to moderate.
COPD	26,9	15,8	Tightness of breath, dyspnea and cough. Decreases mobility, ability to exercise, physical capacity. Effects usually significant.
Hip arthrosis	17,7	16,1	Pain in joints if moving. Decreased mobility, ability to exercise, physical capacity and QoL. Effects from minor to significant.
Knee arthrosis	15,5	24,8	Pain in joints while walking. Decreased mobility, ability to exercise and physical capacity. Effects from minor to moderate.
Low back pain	15,4	16,5	Decreased mobility, ability to exercise, physical capacity, decreased QoL. Effects usually from minor to moderate.
Mental disorders	29,7	30	Decreased social activity, increased depression. Effects from minor to significant.

Coronary heart disease and pulmonary diseases (asthma and COPD) have relatively high prevalence numbers among the elderly. However, with proper medication, their effects to functional capacity can be noticeably reduced. Coronary heart disease can remarkably impair physical functional capacity by reducing duration of exertion, maximal heart rate, systolic pressure, and heart rate difference (maximal heart rate during exercise minus resting heart rate just before exercise) (Kasser and Bruce 1969). Coronary heart disease has also shown to decrease health-related quality of life (HRQL) and increase depression (Taylor et al. 2004, Kasser and Bruce 1969). COPD patients have also been shown to suffer from depression (Light et al. 1985). Musculo- skeletal diseases such as hip and knee arthrosis and low back pain have grown in number during the last few decades due to a major change in working circumstances and work strain.

Musculo- skeletal diseases can cause severe limitations to functional capacity, mainly affecting physical capacity, mobility and QoL (Carmona et al. 2001). Mental disorders, e.g. depression, on the other hand may substantially decrease social activity among the elderly (Kivelä et al 1988, Kivelä and Pahkala 2001). This is especially straining, since they usually have less active social contacts than younger people and the elderly may be ultimately left isolated from all social contacts (Heikkinen and Rantanen 2008).

2.1.4 Future challenges of health care for the elderly

As described earlier, the aging population will present a growing challenge for healthcare. A higher percentage of elderly people in the population escalates the overall healthcare costs (Häkkinen 2008). This is due to a higher prevalence of diseases and greater need for treatment, since there is a need to have more people involved in healthcare (Stults 1984). Aging people also use more healthcare services related to research and treatment (Izaguirre 2004). However, the amount of resources available for healthcare technology in the developed countries is limited (Dai et al. 2009). This creates a need for rapid developments in healthcare technology in order to ease the burden on healthcare staff.

Developing new technology is not enough to fill the void in healthcare services on its own. It is of the utmost importance to stress the need for proactive self-activation in monitoring oneself (Carlson et al. 2001). This means using self-monitoring devices at home, such as blood pressure monitors, heart rate monitors, and pedometers. Especially elderly people should be more self-dependent and self-reliant in taking more responsibility for their own health (Carlson et al. 2001). This would ultimately result in fewer hospital visits, since the elderly people would have better knowledge of their health. In addition, higher self-esteem concerning elderly persons' health will most probably reduce the need for hospital visits, easing the burden on the already stressed healthcare staff.

Another important task for healthcare professionals is to pay special attention to restoring and maintaining the patient's functions, such as cognitive performance (Hansebo et al. 1998). If the current research and treatment practice were to continue, patients would be ordered to undergo bedside treatment for too-long periods of time during research and treatments (Henriksen et al. 2002). Post-surgery patients should be mobilised as soon as possible, since it reduces post-surgery complications (for example pneumonia, deep vein thrombosis, and pulmonary embolism) and improves convalescence (Adams et al. 2007, Henriksen et al. 2002). Making patients rest in wards after, for example, a brain thrombus, cerebral haemorrhage, or stroke should be stopped as well (Adams et al. 2007). The elderly should also be mobilised as soon as possible (Adams et al. 2007). Using traditional technological solutions, round-the-clock staff for elderly care is needed for rehabilitation. To ease this problem, technical solutions for home care should be developed and home-based patient monitoring should be utilised

more thoroughly. In this way patients could be discharged as soon as possible in order to reduce the strain on wards.

As technology has progressed quickly, new solutions are available for monitoring elderly people. However, medical professionals have been slow to adapt to these changes. Here are a few key technological innovations that should play a major role in the hospitals of the near future.

Patient monitoring can be used at home after hospital treatment. Earlier studies suggest that home-based monitoring enhances the possibility of discharging patients from the hospital, reduces the rate of hospital readmission, prolongs event-free and total survival, reduces healthcare costs, and improves the QoL of the patients (Scalvini et al. 2005, De Lusignan et al. 2001). “Healthy patients”, e.g. patients who belong to certain risk groups (diabetes, obesity, and elevated blood pressure), can also be monitored. In this case the doctor wants to know e.g. what the mobility of the patient is and how their blood pressure and heart rate develop during the monitoring period. Evaluating the effects of new medicine often also requires monitoring. Seeing positive results is often highly important for the patients; in other words, the patients want to see a positive development in their weight, blood pressure, or heart rate. A remarkable benefit is that the patient does not always have to seek hospital treatment. Monitoring can be performed at home – even wirelessly – using modern technology.

Home-based cardiac rehabilitation has been assessed and found to be as effective and efficient as centre-based rehabilitation in reducing mortality and cardiac events (Dalal et al. 2010). Home-based programmes provided by “telehealth” show promise in reducing mortality and can lead to clinically significant benefits in cholesterol, blood pressure, and the prevalence of smoking (Neubeck et al. 2009). The advantage of home-based programmes is that they can provide support for these behaviours for longer than the usual few months offered by hospital-based cardiac rehabilitation (Clark et al. 2005, De Lusignan et al. 2001).

Several diseases of the elderly require laboratory monitoring (e.g. DM, hypercholesterolemia, and infectious diseases). It is of the utmost importance to develop methods for gathering samples at home and transferring the results of these samples wirelessly to healthcare stations for evaluation. From there, information on the results and follow-up procedures can be given to the elderly. This reduces the need for patients to travel back and forth between their home and the hospital and it also reduces the strain on healthcare staff.

Patient safety requires the development of patient tracking systems and applications (McShane et al. 1998). High number of injuries associated with falls among the elderly is a major public health concern and has generated a wide range of applied research prompting the development of fall detection diagnosis systems (Noury et al. 2007). Several studies have been carried out to recognise the detection of falls among the elderly at home: Bourke et al. used simulated falls using tri-axial accelerometer sensors

mounted on the trunk and thigh to discriminate between the activities of daily living (ADL) and falls (Bourke et al. 2007). A similar study has also been carried out with bi-axial gyroscope sensors (Bourke and Lyons 2008). Foroughi et al. used video surveillance to detect falls of the elderly in intelligent home environments (Foroughi et al. 2008). In addition, image-based sensors (Lee and Mihailidis 2005) and low-cost infrared sensors (Sixsmith and Johnson 2004) have been successfully used as fall detectors.

Different types of identification tags should be more thoroughly utilised. For instance, deviant movement and fall detection can be registered by tags placed on the floor, bed, clothes, or even shoes. Radio-frequency identification (RFID) tag-based location and identification systems have been developed for monitoring the elderly (Wang et al. 2009, Ropponen et al. 2009). The main focus of the RFID-based systems is not only to locate and identify the patient and cut down on telemedicine costs, but also to provide a continuous communication link between the elderly and caregivers and to allow physicians to offer help when needed (Raad 2009). However, ethical issues related to identifying patients using tags have limited the use of RFID tags (Peslak 2005).

Several mobile phone-based systems have been developed to detect the locations of elderly persons and to transmit notification of their emergency situations (Ogawa et al. 2007, Niemelä et al. 2007, Miyauchi et al. 2005). An example of a mobile phone-based locating application is one developed by Miyachi et al: if the test person's respiration is paused or if they are in an inactive state for a long enough time, the system automatically sends the person's location to caregivers by e-mail and also informs the patient's family of the emergency situation by voice via mobile phone (Miyachi et al. 2005).

New technology has enabled high-level integration wireless devices to be implemented which can replace traditional large wired monitoring devices (Moein and Pouladian 2007). For example, the Ward-in-Hand project is dedicated to tracking down patients wirelessly and developing and implementing a reduced wireless electrocardiograph monitor that is faster and more accurate (Moein and Pouladian 2007). These applications can be accessed quickly and effortlessly using a personal digital assistant (PDA) (Karampelas et al. 2003).

2.1.5 Developing preventive healthcare for the elderly

In addition to having more health problems and using more often medication than younger patients, the elderly people are more likely to have significant difficulties in communication with medical healthcare professionals (Stults 1984). For example, they may fail to report medical conditions because they believe that diseases and disabilities are natural hindrances of aging and that no effective treatment is available (Stults 1984). Another common reason for this behaviour is the fear of being institutionalised (Stults 1984). For several reasons, it is essential for the healthcare system to abandon a disease-

specific approach to preventive health care that emphasises solely the primary prevention or early detection and treatment of disease. It is therefore of major concern for healthcare systems to assess the physical, psychological, and social functions of elderly people (Stults 1984).

Table 5 – Preventive healthcare measures for the elderly (modified from Stults 1984).

Primary Prevention
Immunization
Accident prevention
Physical fitness
Nutrition
Secondary prevention - early detection and treatment
Hypertension (diastolic, systolic)
Cancer (breast, colon, cervix)
Vision deficits
Hearing deficits
Dementia
Depression
Alcoholism
Social support system
Iatrogenic disease: Drug therapy
Urinary incontinence
Podiatric disorders
Hypothyroidism
Tertiary prevention - Rehabilitation
Assessment of physical, psychological and social functions

A proposed list of preventive healthcare measures is presented in Table 5. Primary preventive healthcare measures consist of immunisation (e.g. influenza vaccination), accident prevention, and enhancing physical fitness and nutrition for the elderly. For example, persons older than 65 years account for a staggering 80% of influenza-related deaths and 30% of admissions to hospital (Stults 1984). Similarly, injuries are a frequent cause of death among the elderly (Sahyoun et al. 2001). In addition, physical fitness should be emphasised to prevent poor health and the chance of the elderly developing a disability (Stults 1984). Great emphasis should also be placed on nutrition, since obesity but also malnutrition leads to several health impairments among the elderly (Salihu et al. 2009, Kopelman 2000).

Heart disease (closely linked to hypertension) and cancer are the two leading causes of death among the elderly over 65 years of age and thus their screening and treatment should be promoted (Sahyoun et al. 2001). Special attention should also be paid to the detection and treatment of degradation resulting from aging, such as hearing and vision

deficits, urinary incontinence, hypothyroidism, dementia, alcoholism, and depression, since they often isolate the elderly from their social environment by disabling them (Stults 1984). Alcoholism and depression may even lead to suicide if left unnoticed (Stults 1984, Kivelä et al. 1988). Thus the focus should be placed on improving the social support system for the elderly in order to enhance their independent living in the community (Stults 1984).

Advanced age, in combination with multiple diagnoses, may also cause limitations in both physical and psychological functioning (Hansebo et al. 1998). To comprehensively assess elderly patients it is important to not only successfully identify and treat their medical conditions but to also improve their physical, mental, and social abilities and functions (Stults 1984). If functional deficits or disabilities are found, rehabilitation is applied. If they cannot be adequately restored, the physician may enlist family or community resources to help prevent or forestall increasing dependency and placement into an institution (Stults 1984). This enables the elderly patient not only to live longer, but also to remain physically more healthy and active, reducing and postponing the likelihood of institutionalisation (Stults 1984, Kivelä and Pahkala 2001, Sahyoun et al. 2001). Non-institutionalised elderly people have also been proven to be stronger and more capable of taking care of themselves (Sahyoun et al. 2001).

2.1.6 Care homes for the elderly

The development of the system of care for the elderly is extremely important as a result of the aging of the population (Rimminen et al. 2008). It is becoming increasingly important for countries like Finland to provide home care for their elderly that is as wide and thorough as possible because of the rapidly changing age structure of the population and high cost of hospitals (Rossi 2009). The main focus in building more care homes for the elderly is on avoiding hospitalisation; moving elderly patients from hospitals to care homes substantially reduces the costs of medical treatment (Barker et al. 1994, Ernst and Hay 1994).

Care homes for the elderly are either municipal or privately-owned facilities for old people. Patients whose physical condition is not good enough for them to live at home, but who do not require constant medical attention, may be transferred to a care home for the elderly. In Finland there are over 67,000 people altogether living and being treated in care homes for the elderly (National Institute for Health and Welfare 2009). The accommodation consists of one- or two-room apartments with either constant assisted nursing care or only partial assisted care. This means the nurses may provide, for example, a 24- or 12-hour-a-day service for the elderly residents. The apartments are usually spacious and allow patients with poor mobility to move around easily in them.

2.2 Assessing PWB

2.2.1 Parameters for monitoring PWB

For the past few centuries, a commonplace perspective in western healthcare has been "good general health means no diseases". However, a disease-specific approach to geriatric preventive healthcare will not suffice and thus, during recent decades, healthcare professionals have been working to fix this assumption. The concept of general health consists of a person's physical and psychological well-being and it has been regarded as a holistic phenomenon, in which both the body and mind are well-balanced. (Stults 1984)

Thus a strong need exists to assess physical and mental health and well-being. However, monitoring these parameters requires the appropriate technology. As technology has progressed quickly in recent decades, new technological solutions have created possibilities for the more efficient monitoring of these parameters of general health. In order to answer the challenge of comprehensively monitoring general health, a multi-professional approach, teamwork, and investigation are needed (West and Poulton 1997, Fleming and Blair 2005).

Mood, pain, QoL, and PWB are parameters that indicate the psychological experience of health among patients. They have been found to be efficient indicators for the onset of a disease (Scheier et al. 1989, Paquay et al. 1976, O'Loughlin et al. 2010, Schwenzfeier et al. 2002). Thus it is important to thoroughly understand the meaning of these subjective parameters in order to predict the risks of serious diseases. Many devices and methods have been developed in attempts to monitor these parameters. Traditionally, paper-based forms and questionnaires have been used in healthcare to monitor them, but nowadays more and more electronic methods and devices are being used (Palmblad and Tiplady 2002, Morren et al. 2009, Burton et al. 2007). Several electronic diaries (e-diaries) have been developed since the beginning of the 1990s to measure patients' psychosocial experiences in real time (Shiffman and Hufford 2001). They enable momentary experiences to be assessed several times per day and transferred automatically to nursing staff (Shiffman and Hufford 2001).

Mood, pain, and QoL were chosen from the Resident Assessment Instrument (explained below) as reference parameters for PWB, because they broadly measure the patients' daily routines and they have been proven to be countable indicators for the onset of a disease (Scheier et al. 1989, Paquay et al. 1976, Munk et al. 2008, Elneihoum et al. 1999, O'Loughlin et al. 2010, Katon and Russo 1989, Herrmann-Lingen et al. 2001, Rumsfeld et al. 2003).

Below, pain, mood, QoL, and PWB are explained more thoroughly, along with a few of the most noteworthy applications for these parameters. Only few applications for

measuring pain, mood, QoL and PWB among elderly people have been developed thus far, and therefore this study focuses on applications developed for people of all ages.

2.2.1.1 Monitoring pain

Pain is one of the most widespread and difficult problems the medical community has to face (Latham and Davis 1994). Throughout the late 19th century and the beginning of the 20th century, it was assumed that pain is purely a sensory experience. This is, however, a false assumption. Pain is a subjective experience that is influenced by several psychological variables, such as cultural learning, the meaning of the situation, and attention (Melzack and Wall 1988).

It has been suggested that pain consists of three major psychological dimensions: the sensory-discriminative, motivational-affective, and cognitive-evaluative dimensions. They interact with one another to provide perceptual information on the location, magnitude, and spatiotemporal properties of the noxious stimuli, motivational tendency towards escape or attack, and cognitive information based on past experience and the probability of outcome of different response strategies. These three forms of activity then influence the motor mechanisms responsible for the responses that characterise pain. Thus it needs to be understood that when pain is being monitored, several factors affect the experience of pain and there may be numerous reasons for experiencing pain. (Melzack and Casey 1968)

Additionally, the measurement of pain in disease should not be confused with the experimental measurement of pain. Experimental pain is has been found easier to study since the intensity of the pain-inducing stimulus can be measured (Huskisson 1974). However, the nature of the stimulus in pathological pain is often unknown and its intensity is often difficult to measure (Huskisson 1974). Moreover, the severity of the disease is not clearly related to the pain felt since factors such as individual patient's pain threshold noticeably affect pain (Huskisson 1974).

2.2.1.1.1 Applications for monitoring pain

Several pain monitoring methods and devices have been developed. Traditionally, paper-based questionnaires have been used to assess pain among elderly patients. However, lately electronic devices have been gaining ground in monitoring pain among elderly patients. Some well-known monitoring applications for pain are mentioned below.

Visual analogue scales (VAS) are well-validated and often-used instruments for measuring the intensity of pain and they have been claimed to be the most sensitive method of measuring pain (Bijur et al. 2001, Huskisson 1974). The patients assess their experienced pain level, for example three times per day using a VAS scale from "no

pain" to "severe pain" using a scale from 0-100 mm (Aitken 1969). Extra medication is asked for in an amount corresponding to the evaluations (Bijur et al. 2001). Paper-based and electronic versions of VAS currently exist (Jamison et al. 2002).

Another well-known application for pain monitoring is the McGill Pain Questionnaire. The questionnaire provides quantitative measures of clinical pain that can be treated statistically and is sufficiently sensitive to detect differences among different methods used to relieve pain (Melzack 1975). In the questionnaire, patients describe the areas where they experience pain by using a pen and paper (Melzack 1975). They also assess the quality of the pain, the intensity of the pain, and the physical functioning that causes pain (Melzack 1975). A modern version of the McGill Pain Questionnaire is an electronic pain monitoring device named the PAINReportIT, a computer program for a PC (Wilkie et al. 2003). Instead of using a pen and paper the patients use a touch-screen computer (Wilkie et al. 2003). The PAINReportIT also has some additional questions about pain compared to the McGill Pain Questionnaire and the results can be automatically imported to e.g. a Microsoft Access database for the caring staff for further evaluation (Wilkie et al. 2003).

Impak Health Journal for Pain is an RFID-enabled cardboard foldout printed with a number of questions for patients to answer regarding their pain management. Patients can input their answers to the questions by pressing buttons on the card, which will be collected upon a visit to a physician and placed on an RFID reader to upload the responses into a database. The database may be later accessed by that individual's physician. Patients assess the intensity of their pain when taking their normal pain-suppression dose, upon taking a higher dosage for breakthrough pain, and one hour after taking the medication. The patients can also rate their pain on a weekly basis, on a scale of 0 to 10. The system emits audible feedback to inform the user when a button has been successfully pressed. The journal contains an embedded battery-powered 13.56 MHz RFID inlay that can store data and transmit it to a reader. The data is saved to the RFID tag, which has enough memory resources to store up to two reports daily for 36 days. The system is focused on home-care patients and is still under pilot testing by Meridian Health. (Swedberg 2010)

PIPER (Prompting Intensity of Pain, Electronic Recorder) is a pain monitoring application that has been developed to record the users' intensity of pain. Pain is evaluated on a range of values from 0-6; zero means no pain and six means extreme pain. PIPER is an electronic device that consists of a microprocessor, a small amount of random access memory (RAM), and a software program stored on erasable programmable read-only memory (EPROM). The device has seven buttons that record the pain input from the user. The device then provides audio feedback for the user to inform them that a button has been successfully pressed. The device has a computer connection interface for pain assessment and programming purposes. (Lewis et al. 1995)

DiaryPRO is a software application developed for assessing pain using palm PCs. The electronic diary has been designed to be carried along with them by patients, who assess

the severity of their pain between “not at all” and “extremely” by using a pen and touch-screen. The program includes an alert function to remind the user to use the application. The data can be accessed in real time by the nursing staff. Stone et al. (2003) assessed pain measurement using the application among patients suffering from chronic pain. The purpose of the study was to find out if using an electronic diary gradually affects the intensity of the pain experienced by the patient, if it affects remembering weekly pain, and if daily measurement affects the compliance of the patients. No indications towards gradually altered pain intensity or forgetting weekly pain were found. Compliance with using the electronic diary was 94% or higher. (Stone et al. 2003)

Another application for a palm PC is “e-Ouch”, a software program to monitor perceived pain in teenagers suffering from groin pain. The user interface of the device includes a modified VAS scale for pain assessment. The application was tested in order to evaluate its usage. It was used three times per day. The patients would move a marker somewhere between “no pain” and “very much pain”, after which they were asked to touch parts of a picture depicting a human body – shown on the palm PC display – to illustrate where pain was experienced. The randomly selected young test persons experienced e-Ouch as being pleasant and easy to use and the number of errors concerning the measurement was low. However, some user interface issues were noticed. (Stinson et al. 2006)

Another application for a palm PC with a similar user interface is the “LogPad System”. It has been used in a study to assess weekly remembering to report lower back pain compared to daily reporting using the application. The study results indicated that both methods can be seen as equally valid. Most of the test persons used the LogPad system from home, so the device was connected to a modem and a charger for information transfer purposes. Electronic signature verification was used to identify the test subjects. (Jamison et al. 2006)

2.2.1.2 Monitoring mood

Monitoring and understanding patients’ mood has been found to be an important predictor of their physical health (Scheier et al. 1989). For example, a patient suffering from depression is more likely to be exposed to serious illness than a non-depressed patient (VanItallie 2002). Conversely, a patient expressing optimism is associated with a faster rate of physical recovery during hospitalisation and a quicker return to normal life activities subsequent to their discharge from hospital (Scheier et al. 1989). Different aspects of mood – such as stress – have also been commonly measured to predict diseases in healthcare (Cheng 2010). In particular, chronic stress has been found to be a major risk factor for serious illness (VanItallie 2002). Wijeysundera et al. found that preoperative non-invasive stress-testing was associated with a higher rate of preoperative cardiac procedures, improved survival at one year, and a reduced length of stay in hospital (Wijeysundera et al. 2010).

Mood is also an important parameter in monitoring the psychological well-being of the patient. If the mood results appear to be negative for some reason, it is apparent that the patient being monitored has a problem that should be treated by examining them. The most convenient methods for this are either a home visit or inviting the patient for a check-up visit. It is important to notice the manifestations of change in mood and appropriate measures should be taken if rapid changes in mood are noticed. Mood is a "weak signal" that should be registered as comprehensively and accurately as possible (Becker and Morrissey 1988).

2.2.1.2.1 Applications for monitoring mood

Mood can be assessed by using either paper-based or electronic monitors. Although a few paper-based and electronic mood monitors exist, there is a strong demand for more applications. Some commonly-known mood monitoring applications are presented below.

VADIS is a computer program developed to assess mood. Mood is assessed using a VAS scale. Several VAS scales can be applied and they can easily be modified to suit the users' needs to measure e.g. pain alongside mood. The application requires a PDA device and a digital pen for input. VADIS uses a mobile phone to transfer the mood data wirelessly to a central database. It reminds the patient each time a query is about to be performed. VADIS presents the questions in a random order. To avoid biasing, the orientation of the VAS scale changes randomly. The program sends the information wirelessly to a central database, where nursing staff can analyse the results. (Kreindler et al. 2003)

The Purdue Momentary Assessment Tool is an electronic diary for a palm PC with a VAS scale for measuring mood, alongside other parameters. The recorded information is automatically transferred to a desktop PC. The Purdue Momentary Assessment Tool has been used with schizophrenia patients for a test period of 7 days to assess their mood, location, and previous occurrences, such as situations experienced and hallucinations. The program presented the questions randomly to the test subjects at certain time intervals. The results suggested that electronic diaries were suitable for use with schizophrenia patients. (Weiss et al. 2004, Granholm et al. 2008)

The electronic mood device (EMD) has been developed for measuring mood swings and the intensity of different moods. The objective was to develop a device with easy usage. Mood is measured on a scale ranging from "No" on the left to "Yes" on the right. This scale is divided into smaller intervals. The casing of the device includes a small display used to display the questions. The device must be initialised before use by inputting the mood questions and alert times. The questions are installed by choosing the words that will be shown on the display. An example could be the word "angry", in which case the device would display the question: "Am I angry?" The user would then be required to answer the question using the buttons. (Hoeksma et al. 2000)

A similar application for mood monitoring is a software application named the Experience Sampling Program (ESP). This program also requires the user to initialise it by inputting the questions and times for alerts. At the pre-installed time the program then launches a query. This application can also be used for other purposes, such as pain and QoL questionnaires. (Feldman Barrett and Barrett 2009)

LifeShirt is a tight shirt used to measure e.g. electrocardiograph and respiration. It also includes an attached palm PC, VivoLogi, which is used to enter subjective experiences, such as mood. An example question would be: “Rate your feelings of SADNESS in the past 24 hours.” The user is then asked to answer the question on a scale of 1 to 10 using the palm PC. The main focus of the system is to compare the assessed subjective parameters with the measured physical parameters. (Wilhelm et al. 2005)

Seiko Instruments Inc has developed a wrist computer, “Seiko Ruputer”, to measure subjective experiences such as mood, pain, fatigue, and memory loss. Seiko Ruputer’s interface consists of a display, enter button, and a miniature joystick to describe the subjective perception of experiences on a 21-step scale. A study using the device to assess these parameters has been carried out by Saito et al. (Yoshiuchi et al. 2008, Saito et al. 2005)

The Mobile EMA system was developed for mobile phones to collect information about experiences and moods. The test person receives a text message, clicks on the link provided to proceed into a web-based questionnaire, and answers the questions presented using check-boxes shown on the screen. When a certain threshold limit is passed in the query, an automatic text message is sent to the test person, including either an encouragement or a warning, depending on the query results. This helps the test persons to control their state of health. For example, when depressed test persons have expressed depression symptoms several times in response to queries, they receive the message “take a break and rest”. The Mobile EMA system has been tested among people suffering from depression, vertigo, smoking, and asthma. The survey indicated that the system identified the symptoms accurately and helped the test persons with them and that the response text messages sent by the system led to an improved condition among test persons suffering from vertigo symptoms. Their compliance was 89% without response text messages and 93% with response text messages. (Hareva et al. 2009)

2.2.1.3 Monitoring quality of life

QoL is a measure of perceived psychological well-being and it has been shown to be a good predictor of physical health for elderly people (O’Loughlin et al. 2010). It is also an important outcome to measure when assessing the utility of costly and innovative therapies (Gross et al. 1995). Compared to mood and pain, fewer electronic monitoring

applications for QoL currently exist, since most of them are currently still paper-based solutions.

2.2.1.3.1 Applications for monitoring quality of life

QoL has mainly been evaluated using questionnaire forms and scales. The Medical Outcome Study-Short Form Health Survey (SF-36) is a popular general health questionnaire to monitor HRQL. It consists of 36 questions evaluating the physical, social, and mental aspects of HRQL. SF-36 includes eight subscales: physical functioning, role functioning-physical, bodily pain, social functioning, mental health, role functioning-emotional, vitality, and general health perceptions. The range for each subscale is 0-100. SF-36 has been validated extensively on general populations and different diseases, demonstrating high reliability and good construct validity. (McHorney et al. 1994)

Another commonly used form is the Medical Outcome Study Health form. It was developed for use in clinical practice and research, health policy evaluations, and general surveys. It consists of 20 questions assessing six dimensions of HRQL: physical, role, and social functions, mental health, health perceptions, and bodily pain, as well as a self-report Karnofsky Index and other indicators of QoL. (Gross et al. 1995)

The Hospital Anxiety and Depression scale (HAD) identifies milder cases of depression and anxiety in medically ill patients. It was developed and validated on non-psychiatric medical patients. Items relating to both mood disorder and physical illness have been eliminated. HAD consists of depression and anxiety subscales. The scores on each subscale range from 0 to 21. Scores above 8 indicate that a depressive or anxiety disorder is likely to be present. HAD has frequently been used to assess QoL among elderly patients. (Zigmond and Snaith 1983)

2.2.1.4 Monitoring PWB

The main parameter measured in this study is PWB. It can be seen as an overall parameter illuminating the psychological and physical health of the patient. It is important to notice the difference between the “perceived” and “measured” well-being (Veenhoven 2004). “Perceived” well-being means the experienced state of well-being that is measured, while “measured” well-being does not always accurately reflect the PWB experienced by the patient (Veenhoven 2004). Thus a strong demand exists for accurate monitoring devices for PWB. However, only a few devices have been developed for this purpose.

2.2.1.4.1 Applications for monitoring PWB

The Psychological General Well-being Scale (PGWB) is a 22-item inventory designed to measure subjective psychological well-being in population-based studies (Dupuy 1984). It has been extensively validated and has been proven to possess good psychometric properties in several clinical studies within indications such as hypertension (Omvik et al. 1993) and gastrointestinal symptoms (Dimenäs et al. 1993). PGWB is composed of six subscales providing evaluations of anxiety, depression, vitality, positive well-being, self-control, and general health (Dupuy 1984). Each subscale has three to five items (Dupuy 1984). The subscales range from 0 to 15, 20, or 25 (Dupuy 1984). The overall PGWB index score range is from 0 to 110 (Dupuy 1984).

RaVa is an old and commonly-used Finnish paper-based form to assess the physical and mental well-being of a test subject, giving the test subject an index score between 1.29 and 4.23 or grading the test subject with values 1-6. A low RaVa score means good overall health and a high RaVa score means poor overall health. RaVa is assessed by using a standardised questionnaire that comprises the following parameters: sight, hearing ability, mobility, urine, stools, eating, usage of medicine, ability to dress and wash, memory functionality, and psyche. It is, however, often seen as being an insufficient indicator of the patient's overall health. (Voutilainen and Vaarama 2005, Voutilainen et al. 2004)

RAI is a newer questionnaire that has outstripped RaVa as the most commonly used assessment tool for evaluating PWB among elderly people in Finland. It is also commonly used worldwide. RAI consists of three basic components: the minimum data set (MDS), the triggers, and the resident assessment protocols (RAPs). RAI is a standardised primary screening and assessment tool for health care status. It consists of 18 sections, with items including defined codes concerning physical, psychological, and psycho-social functioning (Hansebo et al. 1998). RAI can help nurses and interdisciplinary teams that work in the public health sector to identify the kind of care given to the elderly and ways to improve it. It allows individualised care plans to be drawn up and identifies the workload involved in each task. However, answering all 160 questions of the standardised RAI questionnaire can take up to an hour and is thus often seen as too laborious for the daily monitoring of patients (Gray et al. 2008, Chaliner et al. 2003, Izaguirre 2004).

Karshmer & Karshmer (2010) developed a solution to monitor the well-being and health of multiple elderly test subjects simultaneously. The system consists of a Macintosh iMac desktop computer with a touch screen attached to a "CardioTech" health monitoring device for easy information input. The user interface includes a computer display with clearly visible questions (in big fonts), along with audible feedback. The subjective questionnaire comprises questions about e.g. PWB and general health using an 8-step scale. After the subjective questionnaire the CardioTech device was used to measure physical parameters such as blood pressure, pulse, and weight. The test results suggested that the system provides a cost-effective solution to assessing well-being and

health among elderly people with low incomes using minimal staff resources. The test persons experienced the system as being pleasant and positive in general (Karshmer & Karshmer 2010).

Below, Table 6 illustrating the above mentioned applications for monitoring pain, mood, QoL and PWB is presented:

Table 6 – Pain, mood, QoL and PWB monitoring applications.

Application Name	Application type	Measurement type	Main focus group
Visual Analogue Scale	Paper-based questionnaire, Software application	Pain	None specified
The McGill Pain Questionnaire	Paper-based questionnaire	Pain	None specified
PAINReportIT	Software application	Pain	None specified
Impak Health Journal for Pain	Hardware device	Pain, medication	Chronic pain patients in home-care
PIPER	Hardware device	Pain	None specified
DiaryPRO	Palm PC application	Pain	Chronic pain patients
e-Ouch	Palm PC application	Pain	Groin pain patients, teenagers
LogPad System	Palm PC application	Pain	Back pain patients
VADIS	Software application	Mood	Medically ill patients
The Purdue Momentary Assessment Tool	Palm PC application	Mood	Schizophrenia patients
The electronic mood device	Hardware device	Mood	None specified
The Experience Sampling Program	Software application	Mood, pain, QoL	None specified
LifeShirt	Sensor shirt	Mood, ECG, respiration	None specified
Seiko Ruputer	Wrist computer	Mood, pain	None specified
The Mobile EMA System	Mobile phone application	Mood	Depression, vertigo, smoking, and asthma
The Medical Outcome Study-Short Form Health Survey	Paper-based questionnaire	HRQL	Clinical practice & research
The Medical Outcome Study Health form	Paper-based questionnaire	HRQL	Clinical practice & research
The Hospital Anxiety and Depression scale	Paper-based questionnaire	Depression, anxiety, QoL	Medically ill patients
The Psychological General Well-being Scale	Paper-based questionnaire	PWB	Population-based studies
Rajala-Vaissi Instrument	Paper-based questionnaire	PWB	Elderly people
Resident Assessment Instrument	Paper-based questionnaire	PWB	Elderly people
Karshmer & Karshmer health monitoring method	Hardware device & software application	PWB, general health	Elderly people

2.2.2 Possibilities for the new technology

Electronic devices have been found to provide sufficient health information and to be as effective as the traditionally used paper-based forms and questionnaires (Jamison et al. 2002, Cook et al. 2004). However, paper-based forms, questionnaires, and diaries are more prone to human error than electronic methods and often patients prefer the electronic methods to the paper-based methods (Van Der Kerkhof et al. 2005, Drummond et al. 1995). The paper-based methods are also usually more time-consuming than the electronic versions (Van Der Kerkhof et al. 2005, Drummond et al. 1995).

Because of their numerous advantages, the electronic versions of paper-based forms and diaries and, especially, electronic devices are replacing the traditional methods of monitoring health. The main advantages of electronic forms and diaries are the fast information transfer and the ease and quickness of analysing information. The time, date, and reminding functions confirm that the information has been registered by the electronic applications at the correct time and thus eliminate measurement errors caused by human error. Several research results have also indicated that patients react more positively to electronic diaries than to paper-based forms and that compliance with using electronic diaries is higher (Morren et al. 2009, Jamison et al. 2006). For example, the chance of error decreases, the information processing becomes faster, and the patients cannot see their previous answers and thus cannot try to change them (Palmblad and Tiplady 2004, Cook et al. 2004). It is also possible to send information to healthcare staff wirelessly in real time using current technological solutions. This enables mood, pain, QoL, and PWB to be measured at home, while still preserving the connection to the healthcare staff.

For example, a study has been performed using a device named “Interactive Voice Response System”, a mobile phone-based application, to collect information on the alcohol consumption of young adults and the associated moods. The method was compared to a traditional paper-based questionnaire by having 10 test persons use the former questionnaire method and 10 persons use the latter. The purpose of the study was to find out if a mobile phone questionnaire is as reliable as a paper-based questionnaire. The study suggested that both methods were equally reliable and that no major differences were found in the alcohol consumption, compliance, and satisfaction levels between the test groups. These kinds of studies confirm the feasibility and reliability of many newly-developed devices. (Collins et al. 2003)

As the main goal of geriatric care is to promote and enhance independent living and functionality among the elderly, the future technological developments will most likely focus on home-based monitoring, telehealth and telecare systems (Paavilainen et al. 2005, Sixsmith et al. 2005). Assistive technology in the form of embedded technological solutions installed in the home environments of elderly persons will enhance their mobility as well as their capability to independently perform everyday tasks (Sixsmith et al. 2005, Brownsell et al. 2005). In addition, embedded telehealth

applications enable healthcare professionals to monitor the elderly, but also enable the elderly to easily communicate with the healthcare professionals, even from bedside, if needed. Thus a popular mindset in geriatrics has been to provide “hospital-at-home”.

Public awareness of diseases and how to use health monitoring devices to find and treat them must also be emphasized among the elderly in the near future (Spokus 2005). Therefore it is likely that various applications and devices providing information about diseases and the appropriate means to handle them will gain ground in geriatric healthcare.

2.2.3 Challenges for the new technology

Designing and implementing new technology to make patient monitoring easier involves several challenges. Perhaps the most important challenges are the system interface, user interface, data transfer, power consumption, and security issues. In addition, usability and feasibility of technical devices assessing well-being among elderly people have not yet been sufficiently investigated.

2.2.3.1 System Interface

Arguably the most troublesome issue for the manufacturers of wireless healthcare technology is developing a common system interface platform for all wireless devices. No standardised interface for wireless devices currently exists and the manufacturers use their own interfaces to protect their market territories. For this reason new wireless devices arriving on the market are quite different in different countries and no established system interfaces exist thus far. Therefore a need exists for a coherent platform that provides open interfaces and has space for wired and wireless solutions and different radio interfaces. This would ease the pressure on the developers of new technologies to integrate their systems with other healthcare systems and provide them with several opportunities to market their new products. This would enhance the overall productivity of new healthcare technology. Health Center has predicted that one of the most difficult challenges is developing an integrated interface for wireless devices. One possibility for this could be an antenna that would work on WLAN, ZigBEE, Bluetooth, UWB, mobile phone, and ISM frequencies. (Alasaarela 2006)

2.2.3.2 User Interface

A badly-designed user interface makes the usage of the electronic device difficult and can cause frustration. This must be avoided because if the patient experiences the device as being difficult to use, there is a risk that the device will be left unused or the results will become biased as a result of the poor data collection method. It is thus highly

important that the data collection method itself does not affect the patients' answers. (Palmblad and Tiplady 2004)

Computer programs assessing health parameters often have a pre-installed default answer value displayed on the computer screen, even before the users input their answers. For example, a program assessing mood can have a default value "normal" shown on the computer display. No default values should be included, because they have been shown to bias the users' answers (Palmblad and Tiplady 2004).

Devices measuring mood, pain, and QoL should be easy to use and the functionality of the device should be easy to learn. Easy device usage reduces the biasing caused by the information collection method. A device with easy usage is also more comfortable to use and will seldom be left unused. Additionally, limiting the number of health assessment questions to 20-30 has been found to improve the utilisation of the device (Morren et al. 2009).

Devices with touch-screen displays have widely gained ground in the consumer electronics market. Development of medical applications utilising touch-screen displays has not been quite as successful in the past, but recently more and more touch-screen applications have been used in medical purposes to assess mood, pain and quality of life (Fann et al. 2008, Koestler et al. 2005, Velikova et al. 1999). Modern touch-screen displays can be considered reliable, easy to use and it is very likely that they will be embedded in an increasing number of medical applications in the near future.

Several electronic monitoring devices and applications do not have an alert function to remind the users in case they forget to use the device. This is especially important when monitoring elderly patients, who often have a tendency to forget. However, the alert function should not be irritating, since it may bias the results towards negative answers.

2.2.3.3 Data transfer

Data transfer is an important part of a healthcare monitoring system. Many devices do not have automatic data transfer to the healthcare staff and the information has to be transferred to the computer manually, for example using a memory card, USB, or serial port (Hoeksma et al. 2000, Lewis et al. 1995). This is difficult and increases the time spent on data logging. It is desirable for the device to perform the data transfer wirelessly. A wireless solution enables the device to be carried along with the patient and makes for easy installation because no cords have to be installed. In addition, wireless data transfer speeds up the patient analysis and treatment.

The more users an electronic non-wireless device has, the more time is needed for the healthcare staff just to transfer the data from the device to a computer. However, an electronic application that only has a few users and does not require quick data transfer may prove to be too expensive for some users. Thus, when electronic monitoring

devices for healthcare are being designed or purchased, careful consideration must be given to how many users the device should have and how fast a data transfer link is required. For example, PAINReportIT transfers the data automatically to a database (Wilkie et al. 2003). This is a functional solution in hospital environments, where all the computers using the program can be connected to the hospital LAN.

2.2.3.4 Power consumption

It is obvious that the optimal power consumption for any device should be as low as possible. This applies especially to portable devices, because the benefits of wireless data transfer are lost when an electric cord is plugged into the device. High power consumption in battery-powered devices leads to shorter usage periods (Bloom et al. 2004). If there are multiple devices, it takes a significant amount of time just to change their batteries. Thus having energy-efficient equipment reduces the amount of power used and saves time that would be spent on changing batteries. Currently, few portable healthcare devices have a long enough battery duration for continuous use (Bloom et al. 2004). The battery duration could be enhanced by using newer microprocessors and the possible readiness states they encompass. The display of a hand-held device can account for nearly 60% of the total system power consumption (Bloom et al. 2004). One strategy that has the potential to reduce this consumption and support a positive user experience is to adopt emerging display technologies (e.g. OLEDs) that support energy-aware interfaces (Bloom et al. 2004).

2.2.3.5 Security

Security is a major concern with all wireless technology systems and devices. The information transferred in hospital environments by using, for example, PDAs and desktop PCs is often critical and securing it is a necessity. Safe data transfer means that outsiders (everyone besides the sender and the recipient) are unable to access the information and it has to be possible to validate its arrival to the recipient afterwards. In addition, both the sender and the recipient have to be reliably identifiable and the information transferred has to remain unchanged throughout the transfer. Hospitals' internal networks are usually protected by firewalls. Firewalls isolate hospital networks from other networks and they monitor the information passing through them. This minimises the possibility of attempts to attack hospital networks from outside. However, firewalls enable the hospital network to access other networks, such as public network services. The safety of wireless devices and applications is improving quickly and devices with high levels of safety are already commercially available. (Alasaarela 2006)

2.3 Assessing service quality

Assessing service quality among the elderly is an important issue, and will be even more so in the near future as a result of the aging demographics in Finland and in the developed countries. If the nursing staff are not able to meet their elderly patients' needs, the patients may feel violated and ignored (Kihlgren and Thorsén 1996, Harrefors et al. 2009). Having a patient thoroughly involved in the care process will probably lead to improved compliance, a return to follow-up care, and better treatment outcomes (Cleary and McNeil 1988, Bedell et al. 1984, Greenfield et al. 1985).

Service quality assessments conducted in hospital environments have indicated that most troublesome issues between patients and staff are not about the quality of care in hospital, but rather communication and trust issues, lapses of information, and poor emotional support from the caring staff (Cleary et al. 1991, Miller et al. 2008). Thus it would seem that the most important aspect of service quality for patients is a psychological and emotional presence and understanding, rather than just the quality of care. Similar results have been observed among elderly people living in care homes (Teno et al. 2004).

Paper-based questionnaires and personal interviewing have been used to assess service quality among the elderly, but they may provide misleading answers. Elderly patients are heavily dependent on the nurses, both physically and mentally (Schell 2001, Cooper and Coleman 2001). They may thus fear upsetting the staff with answers that indicate dissatisfaction. Thus a need exists for a simple, easy-to-use monitoring device for assessing service quality among the elderly.

2.3.1 Parameters for assessing service quality in care homes for the elderly

When service quality in care homes for the elderly is being assessed, the primary goal is to understand the interaction between the patients and the nursing staff. The primary function of the nursing staff is to provide patients with food, clean-up, and medication services. However, the psychological and emotional support from the nurses could be equally important for elderly people living in care homes. Thus it was seen as necessary to include this among the service quality assessment parameters. These parameters were selected by professionals in the field of caring for the elderly who collect a wide range of information concerning the overall service quality of local care homes for the elderly.

2.3.2 Methods to improve service quality in care homes for the elderly

Even though care homes for the elderly in Finland provide a quality service, there are needs, from the side of both the elderly and their family members, to improve the quality of the service. The key findings concerning dissatisfaction have been these:

unmet needs for symptom management, concern about communication with physicians about medical decision making, a lack of emotional support for the family members of the elderly, and a belief that the elderly are not treated with respect. Thus high-quality care for the elderly would ensure the desired physical comfort and emotional support for the patient and that more attention was paid to the needs of the elderly person. Shared decision making should be improved, giving the elderly person more contacts with a physician or member of the nursing staff when needed. The elderly should be treated with a greater amount of respect, since many cases have reported that the opinions and needs of the elderly are often ignored by the nursing staff. More information, emotional support, and coordinated care should also be provided for the family members in order to avoid them feeling unaware and helpless. (Teno et al. 2004)

Nowadays, personal (single perspective) interviews are commonly used when qualitative studies are conducted. This applies to most care homes for the elderly in Finland. However, multi-perspective (group) interviews conducted with patients and their informal and professional carers can generate a richer understanding of the individual needs and experiences of patients and their caregivers and can thus help improve the quality of the service. Multi-perspective interviews can also provide practical recommendations about how to deliver services. They can potentially be useful when seeking to understand the relationships and dynamics among patients, their families, and professional carers and when exploring similarities and differences in their perceptions. Multi-perspective interviews can capture the multidimensional nature of the experience of illness and place this understanding within a familial and health service context. However, there are concerns about the time-consuming nature of the data generation and the fact that fewer participants can be sampled. This has limited the use of this research method thus far. (Kendall et al. 2009)

3 AIMS OF THE STUDY

The specific aims of the present study were:

1. to develop and test the feasibility and usability of a new method – Con-Dis – for monitoring perceived well-being among elderly people;

2. to assess other uses for the new test method in health care practice, especially among an aging population, and

3. to assess the feasibility and usability of the method with other electronic devices developed for monitoring physiological parameters and perceived well-being among old people.

4. to assess the feasibility of the new service concept based on Con-Dis-method applied in practice of care

4 MATERIAL AND METHODS

The present study consists of two main elements, the development of a new electronic device (Con-Dis) designed and developed for monitoring PWB and the quality of health care services among old people and the subsequent field studies evaluating its feasibility and usability for monitoring elderly people.

First, the development of a device to assess PWB and the service quality of health care activities among elderly people was carried out in a laboratory environment at Aalto University, Espoo, Finland. Second, after the laboratory tests, extensive field studies were carried out in care homes for the elderly in Lappeenranta, Finland. The research objective was to thoroughly evaluate the feasibility of the device for gathering PWB and service quality information from the focus group.

4.1 Development of the device and laboratory testing (I)

The device should be capable of regularly collecting PWB and service quality information from elderly people. The usage of the system should be faster and the data collection more efficient and consistent than in the existing well-being questionnaires. The collected measurements should be conveniently and reliably stored and transferred for processing to a PC for diagnosis. The device is expected to give highly countable results and provide clear evidence of the elderly persons' PWB and perceptions of the level of quality of the service received. It is assumed that patients' state of general health can be predicted by the patients' answers about their PWB. The same applies to service quality: if the patients receive poor service they are expected to express it with negative answers. The monitoring device should be designed to be attractive to use and to enable elderly patients to use the system independently on a daily basis. Thus it would give care home staff continuous and reliable information on their PWB and opinion on the quality of the service received. The minimum system requirement for the user interface of this device is three buttons to separate the main human emotions of well-being: whether a person's well-being level is perceived as better than normal, normal, or below normal. More buttons could enable the patient to describe their state of well-being more specifically, but three buttons were seen as being enough for illustrating a human state of PWB and opinion on the quality of the service received. A development version of the Con-Dis device is presented in Figure 5.

Figure 5. The Con-Dis device.

The test arrangement should be carried out by assigning a group of volunteers for a time period extensive enough to validate the functionality of the test system. The test persons should report their PWB a few times per day to verify that the device collects and stores information for further diagnosis and assessment properly. The validity and reliability of the data, including the functionality of the buttons, is then measured. After the test period the results are gathered using a PC (with a memory card reader) and processed with the system software. The aim of the test is to verify whether the device registers the time and date of each button access event correctly.

4.2 Field testing (II-IV)

The field studies were carried out in three care homes for the elderly in Lappeenranta, a city located 250 km east of Helsinki, Finland. Care homes (A) and (C) were municipally owned, while care home (B) was owned by a private foundation. All three care homes were staffed by nurses. All the test subjects had a single room with its own kitchen and bathroom and normal living conditions.

The field testing phase was divided into three sections, all taking place in care homes for the elderly in Lappeenranta, Finland. The first phase of the field testing was to

assess the PWB of the elderly for a time period of two weeks (II). The second phase assessed the perception of the quality of service of the elderly for a two-week time period (III). The final phase was to assess PWB, along with blood pressure, heart rate, and time spent outdoors using multiple devices (IV).

Before the field test period, the test subjects were trained by a nurse to use the Con-Dis device and to fill out the questionnaire that was used for comparison. When assessing PWB, the test subjects were asked to push the buttons in the manner described below.

The “happy face” button should be pressed at the given time intervals if the test subjects assume their well-being to be better than their average. The “happy face” represents a situation in which the test subject feels no abnormal pain, their mental situation does not include depression, and their physical condition is above average at the moment.

The “neutral face” button should be pressed if the test subjects assume their well-being is average. The “neutral face” depicts a situation of a condition of stable well-being for the test subject. Mild but not harmful pain can be accepted and their mental situation and physical condition are seen as average.

The “unhappy face” button should be pressed at the given time intervals if the test subjects assume their well-being is worse than average. The “unhappy face” represents a situation in which the test subject feels moderate or severe pain. The person is suffering from depression and their physical condition may be notably below average.

When assessing the quality of the service received, the test subjects were asked to push the buttons in the manner described below.

The “happy face” button was meant to be pressed at the given time intervals if the test subjects considered the overall quality of the service they received to be satisfactory. They were instructed to press the “happy face” if they were fully satisfied with the general service level of the care home for the elderly.

The “neutral face” button was meant to be pressed if the test subjects considered the overall quality of the service they received to be tolerable. They were instructed to press the “neutral face” if they perceived the general service level of the care home for the elderly as being adequate.

The “unhappy face” button was meant to be pressed at the given time intervals if the test subjects considered the overall quality of the service they received to be unsatisfactory. They were instructed to press the “unhappy face” if they were unhappy with the general quality of the service provided by the care home for the elderly.

The test subjects were asked to contact a selected researcher or nurse if they needed further instructions or assistance in operating the Con-Dis device.

The data were collected from the Con-Dis device by using a Secure Digital (SD) memory card, which included a simple utility program that displays the PWB and received service quality measurement results when connected to a PC.

All the field studies performed were approved by the ethical committee of the Pirkanmaa Hospital District, Tampere, Finland.

4.2.1 Assessing PWB (II)

Ten elderly test subjects (of whom 7 were women) aged 63-89 years (mean 78) were selected for the study. The length of time they had been living in care homes varied from four weeks to five years. Two test subjects lived in care home (A) and six in care home (B). Two test subjects lived at home without assistance. One of the test subjects living in care home (A) used the nursing service and had a walking support device.

To report their PWB, each test subject was asked to assess their present subjective perception of their physical and mental condition. The Con-Dis device was tested in the field study by using a modified questionnaire composed of three RAI questions as a gold standard (Gray et al. 2008, Chaliner et al. 2003). Mood, pain, and QoL were selected because they measure the patients' daily routines in broad terms. All the test subjects were instructed to answer the questions each morning, afternoon, and evening.

They were supposed to report if they felt their mood to be depressed, normal, or good by putting a cross in a box corresponding to one of the three. The same applied to pain: whether the test subject felt no pain at all, a little pain, or constant, bothersome pain. The test subjects' experienced QoL was also measured similarly: whether they were not feeling good, feeling okay, or feeling good. After reporting the RAI parameters, the test subjects reported their PWB by pressing one of the three Con-Dis buttons. The collected results were gathered and analysed. Thus, during the 14-day period each person was supposed to use the Con-Dis device a total of 42 times for PWB evaluations and answer 126 RAI questions about mood, pain, and QoL altogether. The RaVa index was also assessed – once per test person – for comparison with RAI, because the tests have minor differences (Laine et al. 2007).

4.2.2 Assessing service quality (III)

Ten test subjects (six of whom were women) aged 74-89 years old (mean 80) were selected for this study. Three test subjects lived in care home (A) and six of the test subjects in care home (B). One test subject lived in care home (C).

The Con-Dis device was tested in this field study by comparing it to a paper-based questionnaire developed to be used as a reference for the device. The questionnaire comprised four questions that assessed the perceived quality of services concerning

food (restaurant and delivery), clean-up and housekeeping, medication, and the general level of assistance provided by the nurses and other staff caring for the elderly.

Each of the test subjects reported on the overall level of the service received once per day, in the evening. They were asked to report if they perceived the food service they received (restaurant and delivery) as being unsatisfactory, tolerable, or satisfactory. The same three categories applied to the clean-up and housekeeping service they received, the deliveries of medication, and the service level provided by the staff caring for them in general. After reporting these parameters, the test subjects reported their overall perception of the quality of the service by pressing, only once, one of the three Con-Dis buttons (happy, neutral, or unhappy – explained above). The collected results were then analysed. Thus, during the two-week test period each test subject was supposed to use the Con-Dis device a total of 14 times and answer 56 paper-based questionnaire questions altogether.

The patients were informed that the results gained both with Con-Dis and the paper-based questionnaire would be kept private and would not be seen by the staff.

4.2.3 Assessing PWB, blood pressure, heart rate, and time spent outdoors (IV)

Ten elderly test subjects (six of them women) were selected for the study. The test subjects were aged between 69 and 89 years (mean 80). Five of the test subjects lived in care home (A). Four of the test subjects lived in care home (B). One test subject lived at home. All the test subjects were fully able to walk and thus participate in normal outdoor activity for their age group.

In this study the test subjects reported their perceived level of well-being by pressing one of the three Con-Dis buttons (happy, neutral, or unhappy) twice per day – every morning and evening. Each time they pressed one of the buttons they received audible feedback indicating that the button had been accessed. During the test period of four weeks, each test subject answered 57 times altogether. The test subjects reported on their perceived mood, pain, and QoL twice per day. Each morning and evening they reported if they felt their perceived mood was good, normal, or depressed by putting a cross in a box corresponding to one of the three. The same applied to the pain they experienced (no pain, some pain, or constant, bothersome pain) and QoL (good, satisfactory, or unsatisfactory). During the four-week test period, each test subject answered the paper-based questionnaire 171 times altogether. Additionally, an RAVA index was calculated after the test period for each test subject.

Each test subject had a blood pressure and heart rate monitoring device, which they used twice a day, each morning and evening. The blood pressure and heart rate monitoring devices (M6 Comfort, OMRON) were commercially available. The measurement was carried out after sitting for ten minutes at rest with a cuff bound around the upper left arm. The patients measured their blood pressure and heart rate

without the assistance of a nurse. After using the blood pressure and heart rate monitor, the patients recorded their systolic and diastolic blood pressure and heart rate by writing them down twice a day on a paper-based questionnaire form (altogether 171 answers per test subject).

Simultaneously with the other monitoring devices, pedometers (Actiped) were used on the test subjects to monitor their activity outdoors. A monitoring device was attached to each test subject's left shoelace by a nurse at the beginning of the test period. The female test subjects used hard-soled shoes, while the male test subjects used soft-soled shoes. The test subjects were told not to detach the monitoring device at any point of the test period and always to wear the same shoes. The pedometer was only used while outside because while indoors the test subjects never wore shoes and it was not possible to attach the pedometer to the test subjects' socks. The data were collected on a daily basis. Each time the test subjects went outside the pedometer recorded the time and date of their steps in its internal memory.

Table 7 demonstrates the test settings for the performed laboratory and field studies:

Table 7 – Test settings for measuring PWB and quality of service among elderly people.

Study type	Main study focus	Number of test persons	Median age of test persons
Laboratory study	Device functionality	5	31,8
Field study	PWB	10	78
Field study	Quality of service	10	80,1
Field study	PWB, heart rate, time spent outdoors	10	80,1

4.3 Service concept model for monitoring well-being

A reform of home and nursing home patient monitoring is a necessity. Outdated home-based visits are far too time-consuming for continuous patient monitoring. Figure 6 represents a service concept model for home-based patient monitoring.

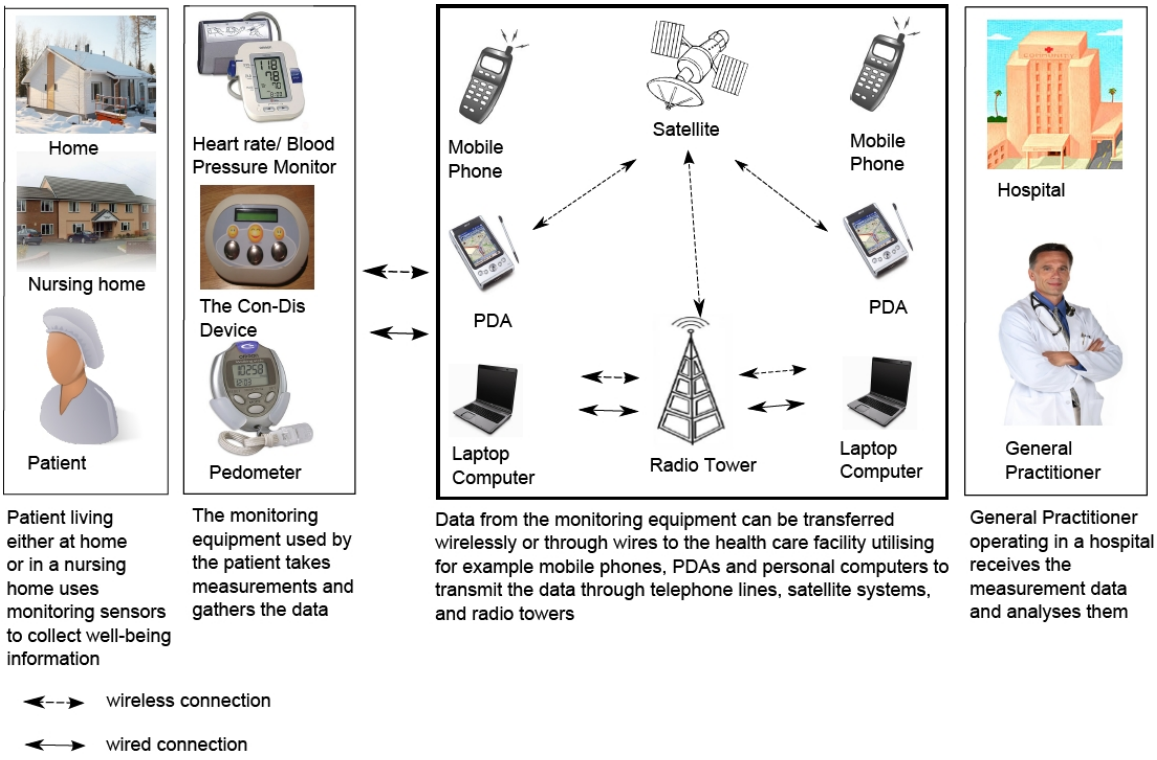

Figure 6. Service concept infrastructure model (modified from Mann 2005).

The patients, who are living either at home or in a nursing home, use medical monitoring sensors to assess their health parameters such as heart rate, blood pressure, physical activity, and PWB. The monitoring equipment records the patients' well-being information and the data can be transferred wirelessly, by wires, or even manually (e.g. entering blood pressure and heart rate values into a mobile phone) to a mobile phone, PDA, PC, or other laptop computer. From there, the information can be transferred wirelessly or through telephone lines to the general practitioner (GP) operating in a health care facility, such as a hospital. The GP can access the medical data for further assessment by using either a mobile phone, PDA, or any form of computer with internet access.

This would enable the healthcare practitioner to receive information on the patient virtually in real time, while sustaining his/her location at the hospital. This allows the GP to operate simultaneously with multiple patients with the same equipment, which makes the GP's work far more efficient.

Receiving PWB information alongside heart rate, blood pressure, and pedometer data could make it possible for the GP to make conclusive evaluations of the overall health of the patient. A sudden decline in PWB and physical activity, along with a rise in heart rate and blood pressure, can indicate a rapid deterioration of the patient's physical health condition and in this case it would be important to assess the patient more thoroughly. On the other hand, stable results from the sensors often indicate a stable physical health condition for the patients.

It should be noted, however, that the Con-Dis device is not suitable for all patient groups. Patients in a significantly poor medical condition, of course, need constant medical supervision and thus are not suitable for the Con-Dis focus group. The Con-Dis device is optimally suited to elderly patients and those belonging to at-risk groups, such as obesity, DM, and CVD patients, but who are in a good enough medical condition to live at home or in a nursing home.

Additionally, using Con-Dis under these circumstances also allows other types of measurements besides measuring PWB. It has already been shown that Con-Dis can be used for service quality assessment, but other uses for Con-Dis can also easily be invented. The “happy face” buttons can easily be used to assess satisfaction in different areas of everyday living, such as the effectiveness of the postal service or overall happiness in family/social relationships. Several ways to use it can quickly be invented and also applied, but it is important to accustom the patient thoroughly to the new parameter, especially if the patient has used the Con-Dis device before for measuring a different parameter. This is a necessity in order to avoid confusion.

4.4 Statistical methods

The probability errors in Figures 7, 8, and 9 were measured using the Matlab (version 7.3.0 R2006b) “Anova” function. Statistical differences in the levels between the groups were tested using the SAS 9.1 program and Pearson Correlation Coefficients.

5 RESULTS

The Con-Dis monitoring device that was developed records and stores the patients' evaluations of their PWB and service quality for later assessment. The first part of the results section covers the technical details of the Con-Dis device and the latter parts cover the laboratory and field testing results.

5.1 Technical details

The Con-Dis device is built around Atmel's ATMega128, an 8-bit microcontroller. The microcontroller is placed on an AVR-MT-128 development board. Unnecessary components were stripped away in order to minimise the board's space requirement inside the ABS plastic device casing. The memory card reader and the buttons on the casing are separately purchased components.

The software for the microcontroller was created using the C-language in the AVRStudio development environment. The GNU Compiler Collection was used to translate the program code for the source language, which is written into the microcontroller's memory in binary code. Software libraries licensed under GNU General Public Licence were used to create the device application. The libraries include AVRLib and Embedded Filesystems Library (EFSL).

The device includes a utility program created using the Visual Basic programming environment. The application reads the information on the (SD) memory card and presents it to the user, both in percentages and as simple events along a graphical time-scale. It is located on the memory card and is started when the user inserts the memory card into the computer. Thus reading the information does not require programs to be installed on the computer. The FAT file system implementation included in the EFSL library is necessary because the device records the registered information into a text file on the memory card. The card is formatted into the FAT file system so that the information can be viewed using a PC – with or without the utility application supplied.

5.2 Laboratory testing (I)

The user interface design of the Con-Dis device emphasises simplicity and the goal was to create an implementation that requires minimal introduction for the target group. The user interface consists of an alpha-numeric liquid crystal display (LCD), an audible output, and three "happy face" buttons. Each button is marked with a smiley face corresponding to the button's function. When one of the buttons is pressed, the device outputs a short sound sample that depends on the button activated. The "happy face"

button emits a happy sound, the “neutral face” button emits a neutral sound, and the “sad face” emits a sad sound to inform the test person that a button has been activated.

The LCD is used to initially set up the device by entering the time and date and the time of possible alerts. The alerts will be activated if the patients forget to use the device at the required time. This causes an audio feedback reminding the patient to press one of the buttons. After the settings have been defined the device shows the name of the user. After accepting the name, the device proceeds to its normal operating mode. In the normal operating mode of the Con-Dis device only the time and date are shown on the LCD for the verification of the basic functionality of the device. The display is not used for giving feedback to the user and thus does not include any essential information concerning the usage of the device. The settings remain in the device memory for a while after the power has been turned off.

The information transfer is performed with a (SD) memory card. Thus a memory card reader had to be integrated into the device. A memory card was inserted for the duration of the test period. The PWB results and input times were recorded on the memory card. After the measurement results had been gathered, the results from the memory card could be read using a PC with a memory card reader.

In the test arrangement being described here the device was placed on a table in a workplace. The test group consisted of five volunteers (healthy male workers, aged 27-45 years) and the test period was five days. The volunteers were given instructions to press a button illustrating their PWB three times per day. After the results had been collected, the program (on the memory card) displayed a statistical figure for the buttons pressed.

According to systematic interviews conducted to the test subjects, most of them experienced Con-Dis as being easy to use but disliked the grip of the device. The bottom of the device does not include surface attachments and thus slides on a table surface when the device is used. Negative comments were also made about the positioning of the buttons. In the prototype version of Con-Dis – used during the laboratory testing – the middle smiley face button was positioned slightly above the other two buttons and thus it was considered that the smiley button attracted relatively more attention than the other buttons. No technical problems were experienced with Con-Dis. The device proved to be stable and gave countable results. No power supply failures or system errors were encountered. The smiley face buttons recorded proved to be 100% correct and the dates and times proved to be 100% correct as well.

5.3 Field testing

5.3.1 Assessing PWB (II)

The test protocol was carried out successfully and all of the Con-Dis devices remained functional and feasible throughout the test period. Each test subject answered over 90% of the total number of questions. One test subject accidentally managed to pull the device's power cord out of the socket but the measurement was not disrupted. Some test subjects unintentionally pressed the device buttons multiple times. Some misinterpretations of the instructions on how to use the Con-Dis device might have occurred, since test subject number 4 answered "neutral" 124 times out of a total of 126. This can be noticed as distorted error margins in Figure 7. Test subject number 9 also had seemingly small error margins, although the results varied more. However, most test subjects understood the instructions correctly. Some test subjects appeared to be happier than others overall. The RAVA index scores did not have a close statistical correlation with either the RAI or the Con-Dis answers.

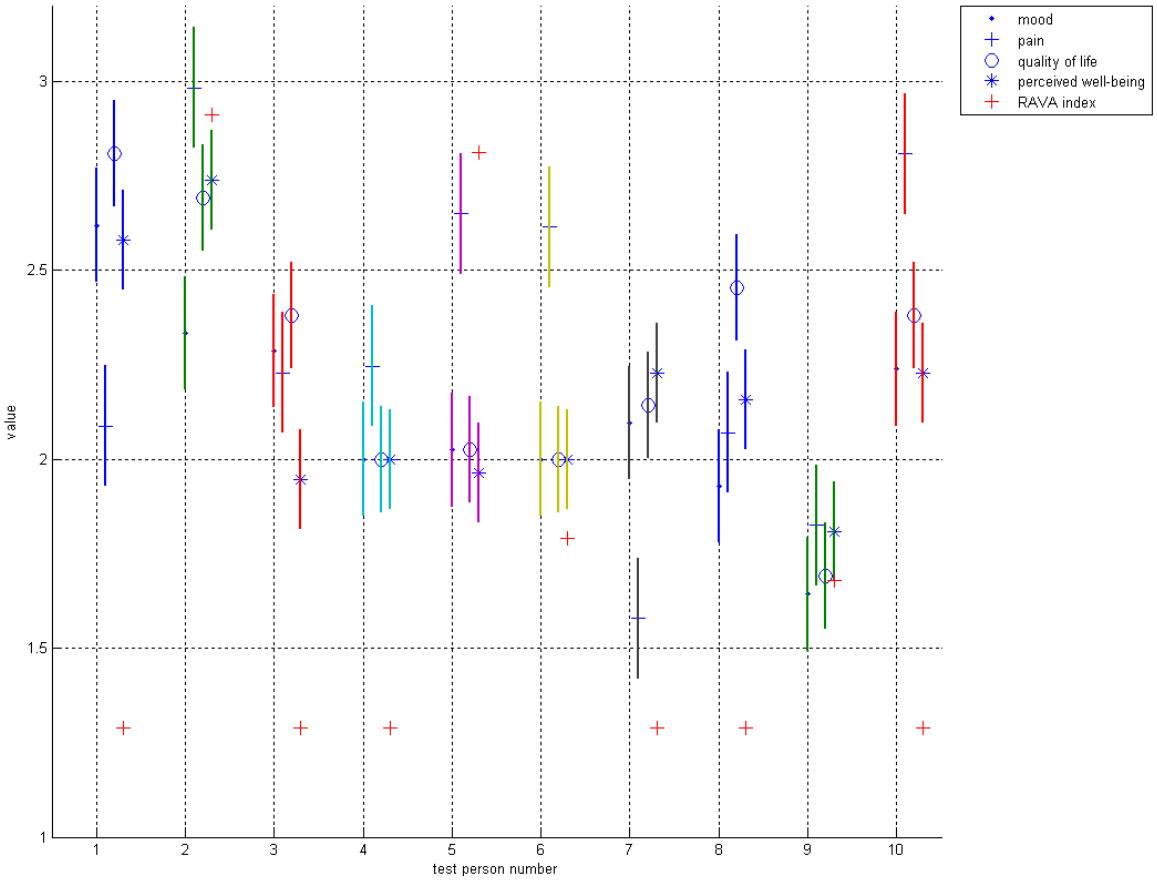

Figure 7 – Data collected from 10 test subjects during a 2-week survey using the RAI questionnaire (mood, pain, quality of life), Con-Dis device (PWB), and RAVA index

(see the text). Each test subject is shown on the x-axis (subjects numbered 1-10) and their reported well-being parameters (as mean values), along with their probability errors, are shown on the y-axis. Values on the y-axis are between 1 (unhappy) and 3 (happy).

On the basis of the results collected from the ten test subjects and their 420 individual markings during the two-week period, the PWB of a test subject correlated closely with the test subject's mood ($r = 0.66$, Pearson Correlation Coefficient) and QoL ($r = 0.68$). On the other hand, their perceived pain level differed significantly from their mood ($r = 0.21$), QoL ($r = 0.28$) and PWB ($r = 0.37$). The association and difference between the mean values in all of the above-mentioned parameters were statistically very significant ($p < 0{,}0001$).

5.3.2 Assessing service quality (III)

No detectable problems were found concerning the technical functionality of the Con-Dis device. All 10 devices remained fully functional throughout the test period. All the test subjects answered at least 90% of the total number of questions. Eight test subjects seemingly understood the instructions that were given and answered the questions in such a way that there was significant daily variation in their answers. Two test subjects either did not fully understand the instructions that were given or else they were very happy with the service provided in the care homes for the elderly: subject 1 answered "good" to 69 out of 70 service-related questions and subject 10 answered "good" to 67 out of 70 questions. However, these answers were included in the present study.

According to the paper-based questionnaire, none of the test subjects were unhappy with the food and restaurant service. Only one test subject gave the food and restaurant service an overall score of 2.0 (tolerable), while the others were happier with the service provided. This was also the case with the clean-up and housekeeping service. One test subject was unhappy with the medical service, but the others saw it as being tolerable or satisfactory. According to the paper-based questionnaire, the test subjects were most satisfied with the general level of assistance provided by the staff (an overall score of 2.69), while the overall service level as measured with Con-Dis was clearly the worst, with an overall score of 2.14. The other three parameters were practically identical, between 2.53 and 2.56.

On the basis of the results collected from the 10 test subjects and their 70 individual scores during the test period, the overall service quality – measured with Con-Dis – did not have a statistically significant correlation with either services concerning food (delivery and restaurant) ($r=0.194$, $p=0.021$), clean-up and housekeeping ($r=0.155$, $p=0.0677$), the delivery of medication ($r=0.096$, $p=0.258$), or the general level of care provided by the care assistants and other staff ($r=0.296$, $p<0.001$) (Figure 8). The only statistically significant correlation was found between the delivery of medication and the general level of care provided by the care assistants ($r=0.509$, $p<0.001$).

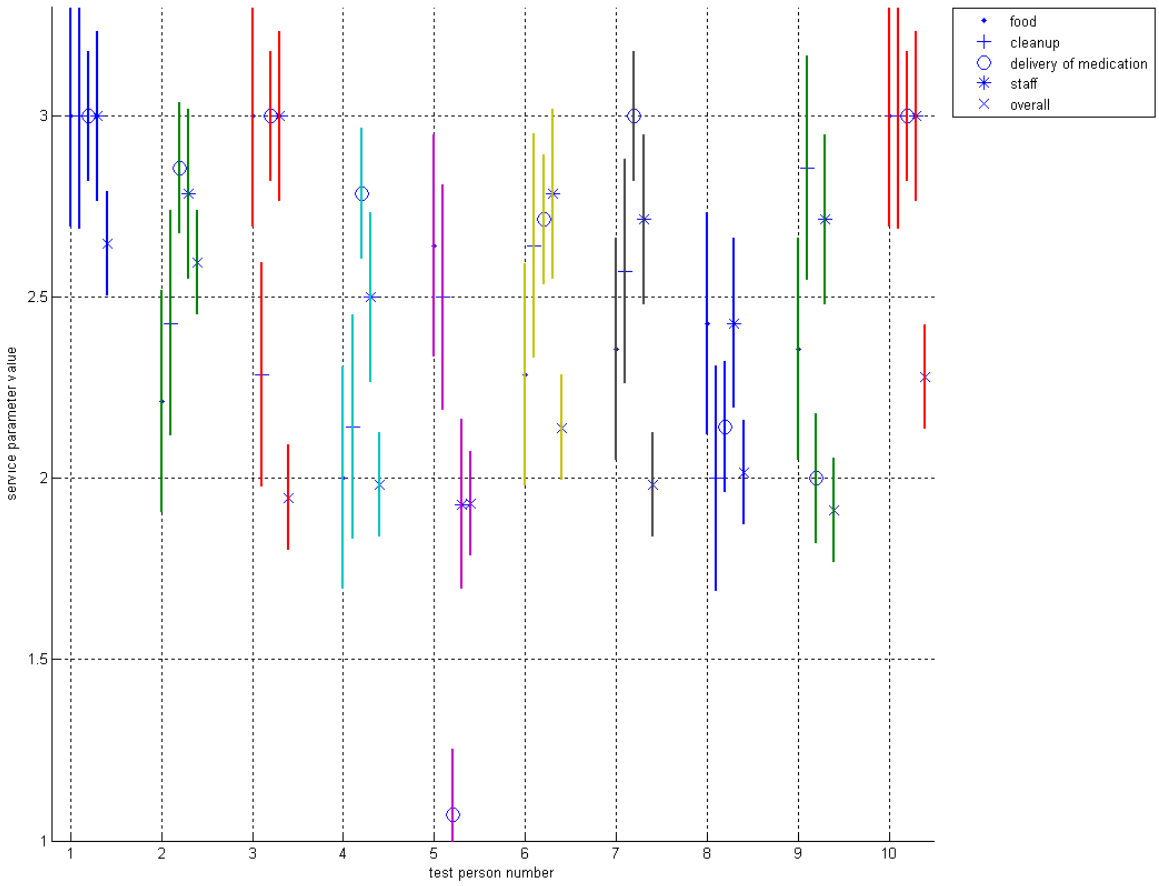

Figure 8 – Data collected from 10 test subjects during a 2-week survey using a questionnaire assessing quality of service (food, cleanup, delivery of medication and staff service) and Con-Dis device (overall quality of service). Each test subject is shown on the x-axis (subjects numbered 1-10) and their reported quality of service parameters (as mean values), along with their probability errors, are shown on the y-axis. Values on the y-axis are between 1 (unhappy) and 3 (happy).

5.3.3 Assessing PWB, blood pressure, heart rate, and time spent outdoors (IV)

All the devices functioned well and no problems concerning their technical functionality were found during the test period. All of the test subjects reported over 98% of the required information about mood, pain, QoL, and PWB. There did not seem to be any misinterpretations concerning the device and each of the test subjects seemed to have understood the instructions correctly, since their answers were registered at the designated moments in time (early each morning and late each evening).

On the basis of the results collected from the ten test subjects and their total of 2280 mood, pain, QoL, and PWB assessments, the PWB of a test subject had a statistically

significant correlation with their mood (r=0.814, Pearson Correlation Coefficient) and QoL (r=0.715). However, PWB did not have a statistically significant correlation with pain (r=0.161). The associations between the mean values in all of the parameters were statistically very significant ($p<0.05$). The RAVA index scores were also calculated for each of the test subjects, but they did not have a statistically significant correlation with mood, pain, QoL, or PWB. In Figure 9 the individual results for each of the test subjects show the close correlation between PWB, mood, and QoL. The difference between PWB, mood, and QoL is minor, but pain can be seen as differing noticeably from the other parameters.

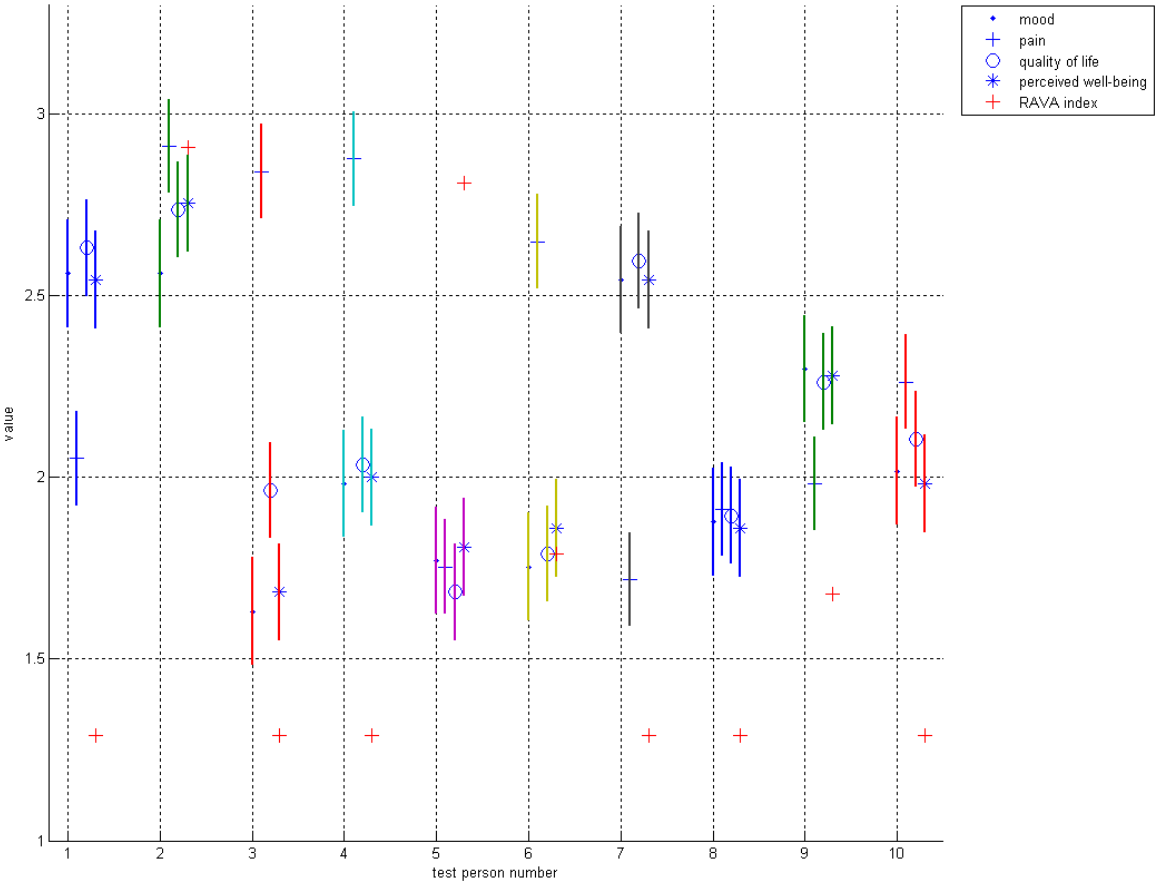

Figure 9 – Data collected from 10 test subjects during a 4-week survey using the RAI questionnaire (mood, pain, quality of life), Con-Dis device (PWB), and RAVA index (see the text). Each test subject is shown on the x-axis (subjects numbered 1-10) and their reported well-being parameters (as mean values), along with their probability errors, are shown on the y-axis. Values on the y-axis are between 1 (unhappy) and 3 (happy).

All the blood pressure and heart rate measuring devices functioned faultlessly throughout the four-week test period. However, test subjects numbers 4 and 10 were unable to monitor their own blood pressure and heart rate as a result of their poor

medical condition. Thus they were left out and this part of the test was carried out with eight test subjects. The remaining test subjects took over 95% of the required measurements. According to the results collected, PWB does not have a statistically significant correlation with systolic blood pressure ($r=0.185$, $p<0.05$), diastolic blood pressure ($r=0.238$, $p<0.05$), or heart rate ($r=0.051$, $p=0.444$).

Most of the pedometer devices remained functional throughout the test period. Two pedometers became detached from the test subjects' (2 and 7) shoelaces during the test period and were lost. Thus their data could not be read and their results were not available for this segment of the study. Additionally, test subject number 5 was discarded from this segment of the study since he had a faulty pedometer device with unreadable data. The device failed to record most of the female test subjects' (test subjects 1, 3, 4, 6, and 9) steps outside and thus the steps calculated by the pedometer were left out of the analysis. The pedometer successfully recorded the duration of time each of the test subjects had spent outside during the four-week time period and thus the time that each of the test subjects had spent outside was analysed in this segment of the study. According to the data that were collected, PWB has a statistically significant correlation with the length of time spent outdoors ($r=0.617$, $p<0.05$).

6 DISCUSSION

The main goal of the study was to develop a new healthcare service concept for monitoring elderly people either at home or in care homes. As a part of developing this concept, a simple but reliable device was developed to gain information from elderly people on their general health condition. This is because we believe that as the number of elderly people is growing and the number of medical professionals is decreasing, these devices are sorely needed at home and in care homes for the elderly to identify needs that can be attended to rapidly.

Medical professionals need to monitor certain parameters of patients' health condition in order to be able to respond if changes occur in vital physiological functions (Burton et al. 2007, Bjordal 2004). A strong need exists to monitor old people closely at home or in care homes for the elderly, rather than in hospitals (Crotty et al. 2005, Fleming et al. 2004). To our knowledge, the Con-Dis device is the first device of its kind used to monitor PWB and the perception of the quality of service among elderly people. The device provides important information about elderly patients for the staff caring for them. PWB is a useful tool for reflecting health developments in the imminent future (Rumsfeld et al. 2003, Burton et al. 2007, Bjordal 2004). Thus the monitoring of PWB may help the medical staff to predict diseases beforehand in order to avoid serious consequences.

6.1 Laboratory testing

The laboratory test period for the Con-Dis device lasted only five days. However, since the purpose of the study was to see how the device collects the information, the time period was seen as sufficient. Some remarks about the functionality of the device were that the sound feedback of the device was observed to be important for the test person in order to acknowledge that the button had been pressed. The device proved to be feasible, reliable, and functional and exhibited no electronic or technical failures. No difficulties were encountered in gathering the data.

However, some development needs were noticed during the laboratory test period. The biggest concern was that the smiley faces must be big enough to be clearly distinguished from each other. There should not be any differences between their positioning so that the test persons are not tempted to press a certain smiley face because of its misleading positioning. Additionally, in this way the smiley faces will be pressed solely on the basis of the PWB. More steadiness and robustness was desired, since the device proved unsteady on the slippery wooden table during the test period. This is especially important for the elderly because of their weakened coordination skills and lack of strength. If the device slides on the surface, it may fall and become susceptible to breakage.

In the future, the information transfer from Con-Dis to a PC is planned to be made wireless. WLAN and modem-based solutions are currently being developed at Aalto University. The ATMEGA128 microcontroller was chosen because of its simplicity of implementation and its low implementation costs (Atmel 2003) and it can be used in the forthcoming versions of Con-Dis as well. The relatively low performance of the microcontroller is not a limiting factor, since the task performed by the device does not require complex calculations.

6.2 Field testing

6.2.1 Assessing PWB

The Con-Dis device functioned well in the first field study (II). The results among ten elderly test subjects were seen to be countable and the sample size was considered sufficient to present a feasibility study of the novel device. The test subjects answered over 90% of the total number of questions, which was considered to be enough to validate the study. Possible limitations of this study were the sample size of only 10 test subjects and the short, two-week time frame. However, we think that the data justify the interpretation concerning the feasibility of the Con-Dis device for use among elderly people. Test subject number four did not seem to have understood the instructions that were given or was otherwise unwilling to express his mood, as he answered “neutral” every time (Figure 7). It might also be possible that he perceived his mood as being stable and neutral throughout the two-week time period. On the other hand, he might have been a person who was not accustomed to self-observation and recognition of his mood, pain, QoL, and PWB fluctuations. However, his answers did not noticeably alter the test results and were thus accepted for inclusion in the study.

Pain differed remarkably from the other parameters measured. This suggests that Con-Dis does not take pain into account specifically when measuring the PWB of a test subject ($r = 0,37$). However, the perceived level of well-being (measured with Con-Dis) was greatly affected by the test subject’s mood ($r = 0,66$) and perception of their QoL ($r = 0,68$). We emphasise, however, that the basic objective of the present study was not to elucidate the complex phenomena of PWB related to pain specifically. In an earlier study, pain had a correlation with patients’ mood and anxiety among chronic pain patients (Linton and Gotestam 1985). According to another study on chronic (non-malignant) pain patients, statistically significant but modest correlations were found between the severity of their pain and their HRQL (Becker et al. 1997). Psychological and social well-being correlated closely as well (Becker et al. 1997). This study, however, does not agree that pain has a close statistical correlation with either mood ($r = 0,21$) or QoL ($r = 0,28$). The difference between the results of previous studies (Linton and Gotestam 1985, Becker et al. 1997) and our findings may arise from the different focus groups. Chronic pain patients’ mood and QoL may be significantly more

affected by pain than was the case with the non-chronic test subjects used in the present study.

6.2.2 Assessing service quality

Few studies carried out thus far have assessed the truthfulness of patient questionnaire answers (Wilson and McDonald 1994, Schaeffer 2000). The study hypothesis was that people living in care homes for the elderly are afraid of answering care home service quality questions honestly. They fear that negative answers would upset the care staff if their responses can be traced back to them and thus anonymity is needed in order to secure truthful responses (Popham 1993). Another reason for dishonest answers could be the strong emotional bonds formed between the nurse and the patient (Davhana-Maselesele and Igumbor 2008). Some studies have indeed suggested that traditional (paper-based) service quality questionnaires are in general unreliable (Williams 1994, Rubin 1990, Sitzia 1999).

According to the field study, the overall service quality (measured with Con-Dis) did not have a close correlation with any of the measured service quality parameters. Answers about the general service level of the care home for the elderly were generally unhappier than the paper-based questionnaire answers. In addition, the standard deviation of the answers recorded by Con-Dis was greater than the standard deviation of the paper-based answers. Even though the test subjects were informed that the answers gained both with the Con-Dis device and the paper-based questionnaire would be kept private, the paper-based questionnaire was visible to the care staff in all cases. Since the Con-Dis device answers were not visible to the nurses, it would indicate that the test subjects answered the Con-Dis device more honestly than they did the paper-based questionnaire. Thus the study seems to support the hypothesis of paper-based questionnaire answers being unreliable.

Even though the Con-Dis answers were unhappier than the other service quality parameters, the fact that the overall service quality did not have any statistically significant correlations with any of the parameters was unexpected. One explanation for this could be that the elderly were so afraid to answer the paper-based questionnaire honestly that the Con-Dis answers differed significantly. Another explanation could be that the patients had difficulty in understanding the meaning of smiley faces or were otherwise unhappy with using the Con-Dis device.

When the paper-based questionnaire answers were examined, only medication and personnel service parameters were seen as having a statistically significant correlation ($r=0.509$, $p<0.001$). This could be predicted, since providing medication for the elderly is often the staff members' duty. No statistically significant correlations were found between the other parameters. The food service was evaluated on the basis of the food delivered to the subjects' apartments and the care home restaurant service. The clean-up service was assessed on the basis of the cleanliness of the homes' shared areas and

apartments. Thus both the food and clean-up service, as parameters, were independent of the overall service quality and it was expected that these parameters would not have statistically significant correlations with other parameters.

Some elderly patients declined to participate in this study, which may bias the results. Having elderly patients as test subjects also poses a risk of confusion with using Con-Dis. Elderly people may have trouble understanding the concept of smiley faces. Two test subjects gave a “happy face” answer to virtually every question. The reason might have been difficulty in distinguishing the faces from each other. This might have been the case if the test subjects had poor eyesight or were confused about the smiley faces and failed to clearly understand what they meant. One patient had exceptionally bad eyesight and a nurse had to help her answer the paper-based questionnaire. This may also have biased the results.

Even though a small chance of bias in the results is possible, it is highly unlikely. Among the subjects who volunteered for the study, some were hesitant to participate at first. Some complained about the strain and burden the study was going to cause them. Thus not all of the test subjects were among the most active, energetic, and social patients living in the care home for the elderly. This should even out any possible bias in the results. Additionally, thorough informative conversations about the Con-Dis device were carried out with the test subjects in order to reduce the chance of confusion about the smiley faces. Furthermore, some of the test subjects had used the Con-Dis device earlier and thus already knew the functionality and meaning of the buttons.

6.2.3 Assessing PWB, blood pressure, heart rate, and time spent outdoors

No problems occurred concerning the technical functionality or feasibility of Con-Dis during the study. Furthermore, no problems concerning the usage of Con-Dis occurred within the test period. An important factor concerning the usage of the device was the received audible feedback after one of the buttons had been pressed. The elderly test subjects reported that this information was essential in order for them to be aware that one of the buttons had actually been pressed. This was emphasised even further when, during the test period, test subject number 7 attempted to press one of the Con-Dis smiley faces (above the Con-Dis buttons) instead of the buttons. Not receiving any audible feedback, the test subject later figured out that it was necessary to press the device buttons instead. In addition to audible feedback, a touch-screen display showing the smiley faces could be used instead of the buttons to simplify the user interface of the device and to avoid similar misunderstandings by the users in the future.

Each test subject seemed to have understood the instructions they were given on how to use the device correctly and answered over 98% of the questions asked about mood, pain, QoL, and PWB. This is enough to validate the study. It also indicates that Con-Dis is a feasible monitoring device for people living in care homes for the elderly and can be used in the circumstances in question. The analysis of the test results shows a strong

correlation between PWB and mood (r=0.814). Additionally, there was a statistically significant correlation between PWB and QoL (r=0.715), but not with pain (r=0.161). In addition, RAVA did not seem to correlate with any of the above-mentioned parameters (Figure 9).

Some studies have suggested that psychological well-being does not have a correlation with blood pressure or heart rate (Wright et al. 2009, Edmunds et al. 2007), but more numerous studies have been carried out that suggest that positive psychological well-being does in fact have an association with reduced blood pressure and heart rate (Papousek and Schulter 2008, Pressman et al. 2009, Perrig-Chiello et al. 2009, Esch et al. 2007). During this study, no problems occurred with the technical functionality of the blood pressure and heart rate monitoring devices. In consequence of their physical handicaps the measurement proved too laborious for two test subjects (numbers 4 and 10) to perform by themselves. As a result of limited nursing staff resources it was impossible for the nurses to perform the blood pressure and heart rate measurements for these test subjects, so they had to be left out of the study. Eight test subjects were able to measure their own blood pressures and heart rates and reported over 95% of these values. PWB did not have statistically significant correlations with systolic blood pressure ($r=-0.185$, $p<0.05$), diastolic blood pressure ($r=-0.238$, $p<0.05$), or heart rate ($r=-0.051$, $p=0.444$). One explanation for this could be the physical activity required to first seek and access the monitoring device and then fasten the cuff and use the device. Even though the test subjects were advised to rest for ten minutes before using the device, it is likely they did not always follow the advice. Poor physical condition may also elevate blood pressure and heart rate levels for a relatively long time after any form of exercise. Thus elderly test subjects measuring their blood pressures and heart rates are susceptible to heightened blood pressure and heart rate levels for these two reasons.

Several studies suggest that exercise and physical activity have a correlation with a perception of psychological well-being (Bailis et al. 2008, Levinger et al. 2009, Opdenacker et al. 2008). Various studies performed on elderly people suggest that exercise and physical activity also show a correlation with their QoL (Rennemark et al. 2009, Coll-de-Tuero et al. 2009). In the present study, two pedometer devices became detached and were lost during the test period. This shows that the fastening mechanism used for the pedometer device was inadequate when used with elderly test subjects. In addition, one of the pedometer devices proved faulty and was thus left out of the study. Three out of a total of ten pedometer devices proving faulty (30% of the total number of devices) is too high a number to be recommended for everyday use with elderly people. Additionally, the pedometers were unable to successfully record all the steps taken outside by the female test subjects. This may be due to the slow and light walking style of the elderly female test subjects. In addition, the snowy ground might have had a negative impact on the steps measured. Thus the time spent on outdoor exercise was measured instead. In this study, the test results for the seven elderly test subjects emphasise that the time spent on outdoor exercise has a statistically significant correlation with the PWB of the test subject.

7 CONCLUSIONS

As a part of developing the new healthcare concept, a new electronic device - Con-Dis - was developed to collect data concerning PWB and information on the quality of the service received from elderly people. The system design was a highly functional, fast, and easy-to-use device for elderly people.

The device was developed and tested in laboratory settings, during which it proved to be reliable and ready for field testing.

The first field study showed that the Con-Dis device presented information that appeared to correlate with the test subjects' health status. Their mood and QoL, but not pain, correlated closely to the PWB level measured by the Con-Dis device.

The Con-Dis device was also used to measure the overall perception of service quality among elderly care home residents. Data collected by Con-Dis did not show statistically significant correlation with any of the service quality parameters (food service, clean-up service, delivery of medication, and service provided by the staff) collected by paper-based questionnaire. The results from the Con-Dis device indicated less satisfaction than those from the paper-based questionnaire and may thus provide more reliable information of the perception of service quality in care homes among elderly care home residents.

The third field study assessed whether the Con-Dis device could be used over a longer, four-week time period together with other health monitoring devices. A blood pressure monitoring device, a heart rate monitoring device, and a pedometer were used to assess the correlation between PWB, blood pressure, heart rate, and the amount of time spent on outdoor activity. The data collected from the test subjects using Con-Dis suggest that PWB has a statistically significant correlation with mood and experienced QoL, but not with pain. PWB also has a statistically significant correlation with the amount of time spent on outdoor activity, but not with systolic blood pressure, diastolic blood pressure, or heart rate.

According to the laboratory and field study data that were gathered and the systematic interviews, the Con-Dis device was remarkably faster and easier to use than most existing paper-based questionnaires, interviews, and diaries. No technical difficulties were found during the laboratory and field testing phases. Old age does not render the device unusable and it could therefore be used as a monitoring device for the elderly. The device also saves the care home employees' time and human resources. The findings emphasise the role of proper training among old people while they begin to use this device.

In conclusion, we suggest that the Con-Dis device can be used as a part of the service concept for healthcare in assessing PWB and service quality information from elderly

people living at home and in care homes. More extensive usage of the device can thus be commenced without any further testing or development. Supported by our positive findings, we also recommend using other electronic monitoring devices alongside the Con-Dis device to provide a more thorough picture of the medical and service needs of the elderly.

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